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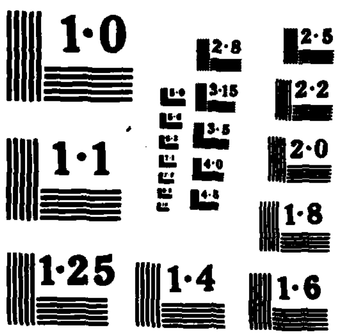
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MAINTENANCE TRAINING SIMULATORS PRIME ITEM DEVELOPMENT SPECIFICATION

MODEL SPECIFICATION AND HANDBOOK

By

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AIR FORCE SYSTEMS COMMAND
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The Public Affairs Office has reviewed this paper, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This paper has been reviewed and is approved for publication.

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This document contains a model specification for maintenance training equipment. An accompanying handbook gives instructions on tailoring the specification for a particular application. The specification allows both training and engineering functional requirements to be stated and is designed to facilitate the inclusion of information related to instructional systems development. The specification provides a standard format while avoiding over-specification of requirements or restriction of contractor engineering decisions. The handbook assists the specification preparer in determining appropriate requirements and gives reasons for these requirements, the values appropriate for particular parameters, source documents, and lessons learned in previous acquisition.

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MAINTENANCE TRAINING SIMULATORS PRIME ITEM DEVELOPMENT SPECIFICATION

MODEL SPECIFICATION AND HANDBOOK

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It is published solely to document work performed.

SUMMARY

Maintenance trainer simulators have become widely accepted and used in many different types of training environments. Nevertheless, serious problems have occurred in the actual acquisition of maintenance simulators due to the failure to write appropriate and definitive specifications for the desired training device. The objective of this effort was to develop a standard systematic procedure for writing effective specifications for any desired maintenance simulator. Pertinent military standards and specifications, military regulations, and other reports were reviewed and consolidated in order to develop an efficient document for writing specifications for procuring maintenance simulators. A model specification and handbook were developed to provide personnel in the System Program Office with a standard systematic procedure and detailed guidance (to include lessons learned from previous procurement acquisitions) for writing maintenance simulator procurement specifications.

PREFACE

This document is an updated and revised edition of the report, Prime Item Development Specifications for Maintenance Training Simulators. This updated copy was produced by Mr. Robert J. Carroll, Project Director under a modification to the original contract listed below. Captain Randy Massey is the Air Force Project Manager. The original document was prepared by Applied Science Associates, Inc. (ASA), Valencia, Pennsylvania, under Air Force Contract No. F33615-78-C-0019. Mr. George R. Purifoy, Jr. was the Principal Investigator and Project Director. The Air Force Human Resources Laboratory (AFHRL), Technical Training Division, Lowry Air Force Base, Colorado was the sponsor. Dr. Edgar A. Smith was the Project Engineer.

This technical paper is one in a series of related reports generated by the study. The primary objective of the study was to build baseline knowledges about techniques, procedures, and principles necessary for broad applications of computer-based simulation for Air Force Maintenance Training.

This technical paper contains a model or generic specification, to be applied by the System Program Office (SPO). The application of the generic or model specification is eventually distributed to contractors or vendors for bids. As a model or generic specification for maintenance training equipment (simulators), the model has provisions for specifying both training requirements and engineering requirements.

Accompanying the general or model specification is a Handbook (Section 3) which provides SPO personnel with instructions for tailoring the specification in specific situations. The Handbook section provides guidance on the selection of appropriate paragraph and subparagraph headings, as well as suggested wording or phrasing for documenting performance parameters. In addition, the Handbook section provides instructions for documenting the results of the Instructional Systems Development (ISD) analysis and for using the document(s) prepared by the ISD team.

The authors wish to acknowledge the assistance and cooperation of the many individuals who contributed information, reviewed preliminary drafts, and made suggestions for improving the document. From ASA, the authors wish to thank Dr. Hobart Harris and Mr. Vernon Hanson for assistance and ideas. Also from ASA, the authors wish to thank the project secretaries, Ms. Ruth Ruckdeschel, Mrs. Tammy Mowry, and Mrs. Pat Jackson for their persistence and patience, and the Graphics Department for their understanding. From the Air Force, special thanks is given to:

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SECTION I

INTRODUCTION

This Technical Paper contains a model or generic specification for maintenance training equipment. This report is divided into three sections. The first section contains the Introduction, the second section contains the model or generic specification, and the third section contains the Handbook that accompanies the model or generic specification. The Handbook contains the instructions that are necessary to tailor the paragraphs and subparagraphs in the model specification for a specific application. The model specification contains blanks to be completed by personnel at the System Program Office (SPO) or by the contractor; the Handbook provides instructions for completing those blanks.

The model specification contains paragraphs and subparagraphs which establish both training requirements and engineering requirements. A review of existing training equipment specifications revealed that often training requirements were poorly defined; i.e., frequently these specifications did not describe how the trainer was to be used in the training program. Without this information, contractors often delivered training devices that were awkward and inefficient to use in the training environment.

> "Although current generation simulators incorporate a number of presumably useful . . . features, several researchers have noted that the design of these features often make them awkward and inefficient to use. It appears that these features were designed without sufficient information about how they were intended to be used during training."[1]

The model specification offered in this paper is an attempt to overcome this problem. Sections of the model are specifically devoted to describing how the trainer is intended to be used in the training program. Although the model specification can stand alone, it was primarily designed to be used with other documents. For example, the specification of training requirements is facilitated if the SPO preparer uses a document produced by the Instructional System Development (ISD) analyst. The document generated by the ISD analyst is reported in another document: <u>ISD-Based Maintenance Training</u>

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[1] Pohlmann, L. W., Isley, R. H., & Caro, P. W. <u>A mechanism for communicating simlator instructional feature requirements</u>. Reported in Proceedings of Inst. Interservice/Industry Training Equipment Conference (p. 132 - 143), November 1979.

Equipment Design Specification.[2] This ISD-prepared document contains descriptions of how the trainer is to be used and specifies many training-related requirements (such as the specification of desired instructional features). In fact, the ISD-prepared document has been designed to become an attachment to the model specification presented here. The ISD document can be included in Section 6 of the Prime Item Development Specification.

Although engineering requirements (such as precautionary markings, maintainability and reliability, etc.) are perhaps easier to specify than training requirements, the preparer of the training equipment specification often has had to search through many military standards and specifications to identify and establish needed requirements. The model specification offered in this document facilitates this process by identifying major paragraph headings and by identifying specific performance parameters (along with their sources).

Once the model is applied in a specific application, a specification is generated that can be distributed to contractors or vendors for bids.

Features of Model Specification

The model or generic specification was designed with the following features in mind:

1. To assure that all the required features of the trainer, as derived from the ISD analysis, are included in the delivered device.

2. To maximize the degree of engineering latitude left to the trainer manufacturer without jeopardizing training effectiveness.

3. To assure that the model specification followed the format offered in MIL-STD-490 for training equipment. Following this format as much as possible would guarantee that users or readers of the specifications would be able to easily find any paragraph or subparagraph heading and/or specific requirement.

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[2] Hritz, Rohn J. & Purifoy, George, R. Jr. ISD-based maintenance training equipment design specification. AFHRL-TP-84-43. Lowry Air Force Base, Colorado: Training Systems Division. 1985. Hereafter referred to as ISD-Based Training Equipment Design Specification.

4. To develop a model specification which is appropriate or applicable to both organizational and intermediate-level maintenance trainers.

5. To allow the preparer maximum freedom in selecting only those paragraphs and subparagraphs which are appropriate or applicable to the specific situation.

6. To develop a specification which would allow training requirements to be traced back to the original ISD analysis; i.e., any training requirement specified can be traced back to where and how the requirement was established. This would facilitate evaluating any such requirements in future trainers. If a requirement derived from the ISD analysis proved useful, then the validity of the ISD analysis would be judged acceptable. On the other hand, if an ISD-derived training requirement proved to be of little value, then that part of the ISD analysis that generated the requirement would be suspect.

7. To develop a specification which incorporates appropriate military standards and specifications in a general sense, but which avoids the problem of over- or under-designing the engineering features of the training device (since many of the military standards were originally written to prescribe the characteristics of operational equipment).

8. To develop a specification which emphasizes performance requirements and functional requirements rather than physical requirements; i.e., all requirements are to be specified in terms of what the trainer or any of its components should do rather than specifying physical characteristics.

The generic or model specification is presented in Section II of this paper.

Features of Model Specification Handbook

The Handbook was designed to assist the preparer in tailoring the model to a specific application. For each paragraph and subparagraph listed in the model specification there is a paragraph or subparagraph (with the same heading and identification number) in the Handbook. For each paragraph and subparagraph the Handbook discusses:

1. Rationale and Guidance. This section discusses why the paragraph or subparagraph is included in the model specification. In addition, it provides guidance to the preparer in determining the appropriateness or applicability of the paragraph or subparagraph to the preparer's specific situation. It also presents a discussion of the factors involved when establishing performance parameters.

2. Performance Parameters. This section discusses what requirements need to be established, as well as how they can be established. In addition, it often provides suggested wording for specifying those requirements. The reader should be cautioned that the suggested wording may not always be appropriate to the specific applications of the specification.

3. Background and Sources. This section specifies the sources used in establishing the requirements. This section also discusses how the ISD-prepared document is to be used.

4. Lessons Learned. This section discusses any lessons the Air Force has learned about specifying the requirement. Often in this section there is a discussion about what things to avoid when specifying a requirement. The Lessons Learned section is intended to be informal. It is anticipated that lessons learned will be added by the Air Force as they are experienced.

The Handbook is presented in Section III of this paper.

Features of the Document

This document (the model specification and the accompanying Handbook) is designed to be dynamic in nature; i.e., a living document. Users of both the specification and the accompanying Handbook should assume the responsibility for keeping the document up to date. If users create new performance parameters (requirements), they should prepare an addendum to this document. Similarly, as users experience lessons learned, the lessons learned section of the Handbook should be expanded. Users who find it necessary to modify or change the specification and accompanying Handbook should be aware that other users may find the changes applicable to their situation. Thus, it is suggested that the Air Force periodically add to this document.

SECTION II

MODEL SPECIFICATIONS

1.0 SCOPE.

1.1 GENERAL.

This specification establishes the design, performance, and test requirements for a maintenance trainer which shall represent: ____
____.

1.2 APPLICATION.

The requirements and verifications contained in this specification apply to maintenance trainers developed for the Air Force.

1.3 DEVIATION.

When any proposed design for a given application will result in improvements in trainer performance, reduced life cycle cost, or reduced developmental cost through deviation from this specification, or where requirements of this specification result in compromise in operational capability, the details shall be brought to the attention of the procuring activity for consideration of change.

2.0 APPLICABLE DOCUMENTS.

2.1 ISSUE OF DOCUMENTS.

a. The following documents of the issue in effect on __________ ____ are applicable to the extent specified herein. In the event of a conflict between the documents referenced herein and the content of this specification, the contents of this specification shall be considered as superseding requirements. Documents cited within the documents referenced herein shall not be applicable to this specification because of such reference.

b. Following is a list of references and documents: __________ ____.

2.2 AVAILABILITY OF DOCUMENTS.

The specifications, standards, and publications listed in subparagraph 2.1b are available as indicated below: ____________
____.

3.0 REQUIREMENTS.

3.1 TRAINER DESCRIPTION.

a. The target population(s) to be trained using the maintenance trainer is(are): ____.

b. The maintenance trainer shall be used for ____________________ ____ training.

c. After successful completion of the training program, graduates shall have a specialty code of ____________________ and shall be capable of performing ____________________-level maintenance.

d. The purpose of the maintenance trainer is to provide training that is directly transferable to the system(s)/subsystem(s) in the following task areas: ________________________________ __________________.

   The specific learning objectives to be achieved by the target population are further specified in subparagraphs 3.2.1.1, 3.2.1.2, and 3.2.1.3 of this specification.

e. The maintenance trainer shall be used in the following way: ____.

f. The maintenance trainer shall have the following components: ____.

   The components are further specified in subparagraph 3.1.3 herein.

3.1.1 ITEM DIAGRAM(S).

____
____.

3.1.2 INTERFACE DEFINITION(S).

____
____.

3.1.3 MAJOR COMPONENT LIST.

The maintenance trainer shall be composed of the following major components: ______________________________.

3.1.4 GOVERNMENT FURNISHED PROPERTY LIST.

The following items shall be furnished by the Government and shall be incorporated into and/or interfaced with the maintenance trainer by the contractor or vendor: ____________________
____.

3.1.5 GOVERNMENT LOANED PROPERTY LIST.

The following items shall be loaned to the contractor or vendor by the Government: ______________________________.

3.2 CHARACTERISTICS.

3.2.1 PERFORMANCE.

The maintenance trainer (integration of all components) shall support maintenance training on ____________________ system(s)/subsystem(s) of ______________________________.

3.2.1.1 TRAINING OBJECTIVES.

The maintenance trainer shall be used to accomplish the following training objectives: ______________________________.

3.2.1.2 TASKS TO BE TRAINED.

The following tasks and/or part-tasks shall be practiced and/or acquired on the maintenance trainer: ____________________
____.

3.2.1.3 MALFUNCTIONS TO BE SIMULATED.

The maintenance trainer shall present and/or simulate the following classes or categories of malfunctions: ____________
____.

3.2.1.3.1 MAINTENANCE CONCEPT OF OPERATIONAL EQUIPMENT.

The maintenance concept of the equipment being simulated is: ______________________________.

3.2.1.4 FIDELITY LEVELS.

The represented system's components shall be physically and functionally simulated to the extent required to meet the training objectives, as specified in subparagraphs 3.2.1.1, 3.2.1.2, and 3.2.1.3 herein. The level of fidelity required is further specified in the subparagraph below.

3.2.1.4.1 FIDELITY LEVELS OF SIMULATED EQUIPMENT.

a. The displays, controls, indicators, Line Replaceable Units (LRUs), etc. specified in subparagraphs 3.1f and 3.1.3, herein, shall have the physical and functional characteristics specified in this subparagraph: ____________ ______________________________.

b. The system(s)/subsystem(s) being simulated shall sense the activation of controls and provide corresponding output displays or indications as specified in subparagraph 3.2.1.4.1a of this specification. The system(s)/subsystem(s) shall be simulated to allow the operation of the system(s)/subsystem(s) without insertion of any special lesson procedures unless otherwise stated herein.

3.2.1.4.2 ENVIRONMENTAL FIDELITY.

The following aspects of the job-performance environment shall be simulated: ______________________________.

3.2.1.4.3 PROBABLE ENGINEERING CHANGES.

a. Any engineering change for the system or subsystem being simulated, specified in an engineering change proposal (ECP) up to and including changes proposed as of ________________, shall be incorporated into the trainer. After this date, the trainer shall be included as part of the system or subsystem equipment ECPs.

b. The maintenance trainer shall be designed to accommodate the possible and probable engineering changes specified within this subparagraph: ______________________________ ______________________________.

3.2.1.5 INSTRUCTIONAL CAPABILITIES.

The trainer has several instructional capabilities based upon the training objectives specified herein. The trainer shall: ______
____.

3.2.1.5.1 INITIALIZATION AND WARM-UP.

a. <u>Warm-Up</u>. The maintenance trainer shall be "ready" for initialization in no longer than ___ minutes after power turn-on under the environmental conditions specified in subparagraph 3.2.5 of this specification.

b. <u>Initialization</u>. Initialization shall include all the functions to be accomplished by the instructor to initialize, verify, and configure the maintenance trainer for training. Initialization shall include the following activities: _____
____.

c. After warm-up, initialization shall take no longer than ____ minutes.

3.2.1.5.2 MALFUNCTION EXERCISE SELECTION.

a. Simulated malfunctions specified in subparagraph 3.2.1.3 of this specification shall be selected and/or made operational in the following manner: ______________________________.

b. Once selected, the effects of a malfunction shall remain until: ______________________________________.

c. The maintenance trainer shall be designed to permit the creation of the future malfunctions specified in subparagraph 3.2.1.3 of this specification.

3.2.1.5.3 MONITORING STUDENT PERFORMANCE.

The maintenance trainer shall perform the following student monitoring functions: ______________________________.

3.2.1.5.4 FREEZE CAPABILITY.

a. The maintenance trainer shall freeze under the following conditions: ______________________________.

b. When unfrozen (deactivated), the maintenance trainer shall:
____.

c. The freeze, when activated, shall cause all displays, controls, indicators, etc. to remain fixed in their position at the moment of the freeze.

3.2.1.5.5 AUGMENTED FEEDBACK CAPABILITIES.

The maintenance trainer shall be: ______________________________
______________________________.

3.2.1.5.6 NEXT ACTIVITY CONTROL FEATURES.

The maintenance trainer shall control the next activity of the student in the following situations: ______________________________
______________________________.

3.2.1.5.7 STIMULUS CONTROL FEATURES.

a. The maintenance trainer shall present the stimuli for the specified learning objectives (and/or exercises) at the following rates: ______________________________.

b. The maintenance trainer shall present the following stimuli at the following signal-to-noise ratios: ____________________
______________________________.

3.2.1.5.8 CUE ENHANCEMENT CONTROL FEATURES.

The following cues (either stimuli or responses) shall be enhanced during the following learning objectives (and/or exercises): ______________________________.

3.2.1.5.9 SIGN-IN CAPABILITY.

a. During sign-in the maintenance trainer shall request the following information: ______________________________.

b. Sign-in shall be the responsibility of: ____________________.

3.2.1.6 UTILIZATION.

The maintenance trainer shall provide efficient training in the following situations: ______________________________.

3.2.1.7 USEFUL LIFE/OPERATIONAL SERVICE LIFE.

a. The maintenance trainer shall have a useful life of not less than ____ years under any of the operating and non-operating environments specified herein.

b. *Other than for periodic and scheduled preventative* maintenance, the maintenance trainer shall operate for ___ hours/day, ___ days/week, and ___ weeks/year.

c. The maintenance trainer shall have an operational service life of not less than ______ hours. Operational service life is defined as the total operating time between the start of the operation and wear-out, where wear-out is defined as the point when overhaul or repair cost exceeds one-half of the replacement cost of the maintenance trainer.

3.2.2 PHYSICAL CHARACTERISTICS.

3.2.2.1 WEIGHT LIMITS.

a. The total weight of the maintenance trainer, in the operating configuration(s) shall not exceed ____ kilograms.

b. Maximum floor loading shall not exceed ____ kilograms per square meter.

3.2.2.2 PHYSICAL DIMENSIONS.

The maintenance trainer shall have the physical dimensions compatible with the following operating and transporting characteristics:

a. *Operating Configuration*

(1) Operating in a room ____ meters (length), by ____ meters (width), by ____ meters (height).

(2) Passage through doorways with maximum dimensions of ____ meters (width), by ____ meters (height).

(3) Passage through hallways with maximum dimensions of ____ meters (width), by ____ meters (height), and a minimum of ____ meters (length) between corners or turns.

b. Transporting/Shipping Configuration

The maximum transporting dimension of the trainer shall be ____ meters (length), by ____ meters (width), by ____ meters (height).

3.2.2.3 MOMENTS.

a. In the operational configuration the trainer and/or any of its separate components shall not be capable of being

overturned by a ____-kilogram horizontal force applied in any direction at the top of the trainer or any of its separate components.

b. In the shipping configuration the center of gravity of the trainer and/or any of its separate components shall not be more than ____ percent of its height above the bottom, more than ____ percent of its length longitudinal from the center, or more than ____ percent of its width fore or aft from the center.

3.2.2.4 WORK AND STORAGE AREAS.

The maintenance trainer shall: ______________________________.

3.2.2.5 ATTACHMENT OF COMPONENTS.

Each major component and subassembly shall: ____________________
____.

3.2.2.6 OTHER DIMENSIONS AND TOLERANCES.

____
____.

3.2.2.7 OTHER PHYSICAL PROPERTIES.

Each component shall be designed and constructed such that parts will not become loose during service or transportation. They shall be built to withstand strains, jars, vibrations and other conditions incident to shipping, storage, installation, and service.

3.2.2.8 SECURITY PROVISIONS.

The following security provisions shall be made: _______________
____.

3.2.2.9 HEALTH AND SAFETY.

All health and safety considerations are specified in subparagraph 3.3.6 of this specification.

3.2.3 RELIABILITY.

a. All practical methods shall be employed that will ensure quality and reliability consistent with the state of technology.

b. Reliability shall be integrated with maintainability efforts in order to achieve the availability specified in subparagraph 3.2.4.1, herein.

c. Reliability shall be predicted during design, measured during testing, assured in production, and maintained in continued use.

d. The maintenance trainer reliability requirements shall be as follows: ______________________________.

3.2.4 MAINTAINABILITY.

a. The contractor or vendor shall not be responsible for maintainability requirements of actual support equipment, tools, or any other Government Furnished Equipment (GFE) as specified in this specification.

b. Maintainability planning and implementation of such planning for new hardware shall include, but not be limited to, necessary maintainability analysis during design, measurements during testing programs, and necessary redesign anytime acceptable levels of availability cannot be attained.

c. The maintenance trainer maintainability requirements shall be as follows: ______________________________.

3.2.4.1 AVAILABILITY.

The availability of the maintenance trainer shall be a minimum of: ______________________________.

3.2.4.2 FAULT ISOLATION.

a. A fault isolation system for the maintenance trainer shall be provided and shall isolate replaceable units (RUs) where an RU is defined as: ______________________________.

b. The system shall be designed such that all faults can be isolated to an RU.

c. Isolation requirements are further specified in subparagraph 3.2.4.2.1 of this specification.

3.2.4.2.1 ISOLATION REQUIREMENTS.

a. The fault isolation system shall isolate faults to the RU limits specified within this subparagraph (item c below).

b. The isolation system shall function such that the isolation shall be accomplished within ____ minutes.

c. The RU limits shall be: ______________________________.

3.2.4.3 BUILT-IN TESTS, SELF-TESTS, AND DIAGNOSTIC TESTS.

The maintenance trainer test requirements shall be as follows: ____
____.

3.2.5 ENVIRONMENTAL CONDITIONS.

The maintenance trainer, including all the components, shall be designed for operation and storage within the following limits.

a. Operational

(1) Temperature: ____ to ____ degrees C.

(2) Relative Humidity: ____ to ____ percent (non-condensing) at ____ °C.

(3) Atmospheric pressure: sea-level to ____ meters altitude.

b. Non-Operational

(1) Temperature: ____ to ____ °C.

(2) Relative Humidity: ____ to ____ percent (non-condensing) at ____ °C.

(3) Atmospheric pressure: sea-level to ____ meters altitude.

3.2.5.1 OTHER ENVIRONMENTAL CONDITIONS.

The maintenance trainer shall meet the following additional environmental condition requirements: ______________________.

3.2.6 TRANSPORTABILITY.

a. Design for transportation shall be based on an expected relocation of the trainer on a ____ basis during its life expectancy.

b. The maintenance trainer transportability requirements shall be: ______________________________________.

3.2.6.1 DISASSEMBLY FOR SHIPMENT.

____
____.

3.2.7 DELIVERY.

The maintenance trainer delivery requirements shall be as follows: ______________________________.

3.2.7.1 INSTALLATION.

The maintenance trainer installation requirements shall be as follows: ______________________________.

3.3 DESIGN AND CONSTRUCTION.

Major considerations of design and construction shall be performance, safety, availability for training, reliability, maintainability, accessibility, and life cycle cost to the Government.

3.3.1 MATERIALS, PARTS, AND PROCESSES.

Materials, parts, and processes shall be selected in accordance with MIL-STD-143, unless otherwise specified herein. However, it is intended that the contractor or vendor be permitted maximum freedom in selecting processes, parts, and assemblies to achieve the required quality and performance at minimum life cycle cost. To permit this flexibility and retain adequate quality, the contractor or vendor shall: ______________________________.

3.3.1.1 PARTS CONTROL PROGRAM.

The parts control program shall be: ______________________________.

3.3.1.1.1 SELECTION OF PARTS.

In addition to the requirements specified in paragraph 3.3.1.1 of this specification, the following requirements shall apply: ______________________________.

3.3.1.1.1.1 PARTS DOCUMENTATION.

Parts documentation requirements shall be as follows: ______________________________.

3.3.1.1.1.2 PARTS CONTROL EXEMPTIONS.

Items exempt from parts control shall be: ______________________________.

3.3.1.2 CONDUCTOR IDENTIFICATION.

Conductor identification requirements shall be as follows: ______
____.

3.3.1.3 TERMINAL ENDS.

Terminal ends shall have the following requirements: ___________
____.

3.3.1.4 SPARE CONDUCTORS.

a. Provisions for spares shall be: ____________________________
   ____.

b. The following shall be exempt from the requirements above:
   ____.

3.3.1.5 FINISHES AND PROTECTIVE COVERINGS.

The finishes and protective coverings requirements shall be as follows: ____.

3.3.1.6 POWER.

3.3.1.6.1 PRIMARY POWER SOURCE.

The maintenance trainer shall be designed to operate from the following power source(s): __________________________.

3.3.1.6.1.1 TOLERANCES.

Unbalanced line currents in the systems shall not exceed ____ percent of the average simultaneously measured line current. The power factor measured at the primary power source of the total inputs shall not be less than ____ percent for any mode of operation. The training device shall be protected from permanent damage, alteration of characteristics, and loss of memory due to total power failure.

3.3.1.6.2 CIRCUIT DESIGN.

____
____.

3.3.1.6.3 POWER SUPPLIES.

The maintenance trainer power supply requirements shall be as follows: ____________________.

3.3.1.6.4 OVERLOAD PROTECTION.

The maintenance trainer overload protection requirements shall be as follows: ____________________.

3.3.1.6.5 UTILITY POWER.

The utility power requirements shall be as follows: ____________________.

3.3.1.6.6 MAIN POWER DISTRIBUTION PANEL.

The main power distribution panel requirements shall be as follows: ____________________.

3.3.1.6.7 POWER INTERRUPTION AND TRANSIENTS.

a. The maintenance trainer shall be protected from permanent damage and modification of characteristics and loss or change of computer-stored memory information resulting from the following nonsimultaneous conditions of power sources: ____________________.

b. The design of the trainer shall be such that when a power interrupt occurs which causes an equipment shutdown, the point at which the training was interrupted shall be identified.

3.3.1.6.8 GROUNDING.

The grounding requirements shall be as follows: ____________________.

3.3.1.6.9 WIRING, GENERAL.

____________________.

3.3.1.6.9.1 WIRING REQUIREMENTS.

The wiring requirements shall be as follows: ____________________.

3.3.1.7 MECHANICAI CONNECTORS.

Mechanical connector requirements shall be as follows: ____.

3.3.1.8 TIME TOTALIZER.

The time totalizer requirements shall be as follows: ____.

3.3.1.9 SCREW AND PIPE THREADS.

Screw and pipe thread requirements shall be as follows: ____.

3.3.1.10 THERMAL DESIGN.

Thermal design requirements shall be as follows: ____.

3.3.1.11 FASTENERS.

Fasteners used on the trainer shall meet the following requirements: ______________________.

3.3.2 ELECTROMAGNETIC COMPATIBILITY.

The maintenance trainer shall have the following electromagnetic compatibility requirements: ______________________.

3.3.3 NAME PLATES AND PRODUCT MARKING, GENERAL.

a. Unless otherwise specified herein, name plates and product markings shall be: ______________________.

b. Control panel markings shall be: ______________.

c. Abbreviations used in marking shall be: ____.

3.3.3.1 NAME PLATES.

Name plate requirements shall be as follows: ____.

3.3.3.2 PARTS IDENTIFICATION.

The parts identification requirements shall be as follows: ____.

3.3.3.3 COVER MARKINGS.

Cover marking requirements shall be as follows: ________________________________.

3.3.3.4 PRECAUTIONARY MARKINGS.

The precautionary marking requirements shall be as follows: ________________________________.

3.3.3.5 SAFETY MARKINGS.

The safety marking requirements shall be as follows: ________________________________.

3.3.3.6 ELECTRICAL POWER MARKINGS.

The electrical power marking requirements shall be as follows: ________________________________.

3.3.3.7 SHIPPING AND STORAGE MARKINGS.

Shipping and storage marking requirements shall be: ________________________________.

3.3.3.8 OTHER MARKINGS.

____

____

3.3.4 WORKMANSHIP.

The trainer shall meet the workmanship requirements specified below: ________________________________.

3.3.5 INTERCHANGEABILITY.

The interchangeability requirements shall be as follows: ________________________________.

3.3.6 SAFETY, GENERAL.

a. The design and construction of the maintenance trainer shall consider optimum safety of personnel when installing, operating, adjusting, maintaining, and moving the maintenance trainer, either during operation or non-operation. The training device shall conform to the health and safety

requirements of Requirement 1 of MIL-STD-454 and MIL-STD-1472, unless otherwise specified directly below. The procedures described in MIL-STD-882 shall be used to minimize potential hazards and to reduce the possibility of system degradation and personnel injury, unless otherwise specified directly below.

b. The Military Standards reference above shall apply, except as stated below: ______________________________.

3.3.6.1 HAZARDOUS MATERIAL.

a. Materials used in the construction of the maintenance trainer shall not support the propagation of flame; all pyrotechnics (missile warheads, propellants) shall be inert.

b. Where the generation of toxic or noxious gases cannot be eliminated, the design effort shall be toward the control and minimization of these hazards.

3.3.6.2 FIRE DETECTION.

The fire detection requirements shall be as follows: __________
____.

3.3.6.2.1 FIRE ALARM.

The fire alarm requirements shall be as follows: ____________
____.

3.3.6.2.2 FACILITY FIRE CONTROL INTERFACE.

Facility fire control interface requirements shall be as follows:
____.

3.3.6.3 OVERHEAT SENSING.

The overheat sensing requirements shall be as follows: ________
____.

3.3.6.4 FIRE STOP SEALING.

____
____.

3.3.6.5 EMERGENCY POWER-OFF.

a. The emergency power-off requirements shall be as follows:
____.

b. The emergency power-off switch shall: ____________________
____.

3.3.6.6 OTHER SAFETY REQUIREMENTS.

____

____

3.3.6.7 ACOUSTIC NOISE.

3.3.6.7.1 HAZARDOUS NOISE.

a. The sound level and exposure time in all areas where the instructor or student might be working shall be held below the values calculated from the following formula:

$$T \triangleq 16 \div 2\ (L-80)/4$$

where T = Duration of Total Daily Exposure in hours.
L = Noise Level in dBA.

b. The maximum dBA shall be: ______________________________.

3.3.6.7.2 SPEECH INTERFERENCE NOISE LEVEL.

a. The noise level at student and instructor stations shall not exceed an articulation index (AI) of 0.7, where the AI is determined by the Octave Band Method.

b. Exception: Where simulated sounds reflecting actual aircraft conditions for the student(s) violate the AI above, the requirements of this paragraph are void for the time period that such simulated sounds are actuated, except that the limits in paragraph 3.3.6.7.1 herein shall not be exceeded.

3.3.6.8 SAFETY DESIGN.

The safety design requirements shall be as follows: ____________
____.

3.3.7 HUMAN PERFORMANCE/HUMAN ENGINEERING.

In order to achieve optimum performance of the instructor, student, and maintenance personnel, and to assure a high degree of man-machine compatibility, the trainer shall: ______________
____.

3.4 DOCUMENTATION.

Documentation shall be provided as specified in this specification and on the Contract Data Requirement List (CDRL).

3.5 LOGISTICS.

3.5.1 MAINTENANCE CONCEPT.

a. The maintenance concept of the proposed maintenance trainer shall be: ______________________.

b. The following personnel shall have the responsibility to update the trainer: ______________________ ______________________.

3.5.2 SUPPLY.

Supply requirements shall be as follows: ______________________ ______________________.

3.5.3 FACILITY AND FACILITY EQUIPMENT.

The facility and facility equipment requirements shall be as follows: ______________________.

3.6 PERSONNEL AND TRAINING.

3.6.1 PERSONNEL.

The maintenance trainer shall be designed to be updated, maintained, and operated by: ______________________ ______________________.

3.6.2 TRAINING.

The training of personnel requirements shall be as follows: ______________________.

3.7 MAJOR COMPONENT CHARACTERISTICS.

3.7.1 INSTRUCTIONAL SYSTEM PROGRAMS.

a. The instructional system programs, as defined herein, shall support the trainer and its training mission as defined herein.

b. All instructional system programs specified herein shall be considered as part of the computer program system and, as such, shall meet the requirements specified in subparagraph 3.7.2 and its subparagraphs. Additionally, the instructional system programs shall meet the requirements specified in this subparagraph and its subparagraphs.

c. All instructional system programs specified herein shall be interactive, permitting the instructor to modify the status of the system or subsystem being simulated as well as alter the instructional features parameters controlling the learning situation, so that training exercises or problems can be created for training purposes.

d. The instructional system programs shall be functionally organized as follows: ______________________________
____.

3.7.1.1 GENERAL REQUIREMENTS.

All interactive instructional system programs specified herein shall have the following requirements:

a. Responses to the interactions shall be made by the instructor. All responses shall be straightforward and require the instructor to enter simple commands, words, phrases, or codes on the provided keyboard.

b. All computer-generated questions requiring an instructor response shall be displayed on the provided display system.

c. All responses entered by the instructor shall be displayed on the provided display system.

d. Provision shall be made to obtain a hardcopy printout of all computer-generated questions and instructor input to those questions upon instructor demand.

e. All interactive sessions shall be designed to permit the instructor to change or alter an input previously made, without the need to restart the interactive session. Changes or alterations shall be requested before the input information is received by the simulation program requiring or using the input information.

f. All response opportunities shall have built-in edits. If a command, word, phrase, or code entered by the instructor is out of range or otherwise illegal to the using software, the interactive program shall generate error messages on the display system.

g. All response opportunities shall have default values, if no input is entered by the instructor. All default values shall be identified at the critical design review.

h. Once all parameters have been entered by the instructor during an interactive session, the interactive software shall ask the instructor if the input is to be saved. If the input is to be saved, the interactive software shall add the exercise automatically to the exercise menu, allowing the entire exercise to be retrieved upon instructor request.

i. Once input information is stored, software shall be provided which will:

- Delete the newly created exercise from the menu.

- Modify or edit any parameter, word, command, or phrase entered, without the need to restart the interactive session.

j. Interactive programs shall temporarily alter any individual parameters specified herein in less than 10 seconds without permanently altering the initialization set.

k. ____
____.

3.7.1.2 TRAINING/SIMULATION PROGRAMS.

The training/simulation program requirements shall be as follows:

a. Interactive software shall be provided which allows the instructor to change the status of the system being simulated by altering values in existing data bases (within specified units of those values) or by supplying commands which require the simulation software to change the status represented by the simulation software.

b. Those parameters which can be changed or altered by the instructor using this interactive software shall be identified in the critical design review. Also identified shall be the ranges of those parameters which can be entered by the instructor.

c. ____
____
____.

3.7.1.3 INSTRUCTIONAL FEATURES PROGRAMS.

Instructional features programs shall have the following requirements:

a. The following instructional features programs shall be provided: ____
____.

b. The contractor or vendor shall furnish, at the critical design review, scenarios for each of the instructional features programs listed above. These scenarios shall include, as a minimum, the following:

(1) A description of the purpose of each program.

(2) A listing of the parameters under the instructor's control for each program; i.e., the parameters that can be entered by the instructor, the default values, and the possible range of instructor input.

(3) A step-by-step description of how the program is used, including illustrations.

(4) A description of how each program can be used with other instructional features programs to create controls over the learning environment.

c. ____
____.

3.7.1.4 INSTRUCTIONAL TEXT PROGRAMS.

The instructional text programs shall have the following requirements: ____
____.

3.7.1.5 DOCUMENTATION.

a. All interactive programs specified herein shall be delivered in object format on magnetic disk and magnetic tape. Source code shall also be provided on ______________________________.

b. Each interactive program specified herein shall have a user's manual. This manual, as a minimum, shall contain:

   (1) A description of the program.

   (2) An explanation of the parameters that can be specified (including the range of legal entries).

   (3) A dictionary of any terms or commands that are used during the interactive session.

   (4) An explanation of the effects of using any entered terms or commands.

3.7.2 COMPUTATIONAL SYSTEM.

3.7.2.1 COMPUTATIONAL RESOURCES.

The Trainer Computational Resources, hereafter referred to as the Computational System and including the Computer Program System (CPS), is herein defined to include all digital processing equipment, interface hardware, peripheral equipment, and associated computer programs/data used to operate and support all major components and subsystems of the training device. Unless noted herein, all computer programs/data (including firmware) used in the development, operation, maintenance, and support of the training device are considered to be part of the CPS and as such shall satisfy all requirements specified herein. Computational Resources shall be documented as required to support the day-to-day operation, mission support activities, modification support activities, maintenance, and test of the trainer.

3.7.2.1.1 COMPUTATIONAL SYSTEM HARDWARE.

Hardware shall be selected for the Computational System which shall be capable of processing the total Computer Program System. The selection of Computational System hardware shall be designed to eliminate potential interface problems and minimize maintenance complexity, and to ensure supportability for the specified useful life of the trainer. Computer vendor-supplied hardware ______ be modified. All Computational System hardware shall be designed to provide and include spare capacities and means to measure spare as specified herein.

3.7.2.1.1.1 MULTIPROCESSOR/MULTICOMPUTER COMPLEX.

If a multiprocessor and/or multicomputer complex is used to meet the operational requirements of the trainer, the following requirements shall be met:

a. The configuration of processing units, interface hardware, and peripheral equipment into a multiprocessor computer configuration and the combination of these computers into a multicomputer complex shall be designed to eliminate nonproductive idle time created by inefficient processor synchronization and intercommunication except on queued microprocessors.

b. Means shall be provided for efficient buffering of data and instructions for communicating and downloading between processors (as necessary), random access memory (RAM), and mass storage equipment.

c. Each computer configuration (mini or micro) shall be capable of being loaded, initialized, and reinitialized independent of all other computer configurations such that in the event of a soft failure of that computer configuration and the associated computer programs/data, the entire computational complex will not require reinitialization resulting in the loss of the training mission.

3.7.2.1.1.2 COMPUTATIONAL SYSTEM HARDWARE DOCUMENTATION.

Documentation for the Computational System hardware shall be provided with the trainer. The documentation provided shall support the operation, mission support activities, modification support activities, maintenance and test of the hardware. All commercially available vendor manuals shall be provided for vendor hardware used in the Computational System. Hardware designed or modified for the trainer shall be fully documented as specified herein.

3.7.2.1.2 COMPUTER PROGRAM SYSTEM.

All computer programs and data (software and firmware) used in the trainer collectively constitute the Computer Program System. The CPS shall support the total trainer mission including training and evaluation of students, maintenance, test, and lesson and modification support. As required by this specification, CPS computer programs/data shall be provided for all major component subsystems. The CPS shall be designed to preclude redesign and redevelopment as the result of the incorporation of computer vendor hardware, software, and firmware updates or revisions.

3.7.2.1.2.1 PROGRAMMING LANGUAGE.

The CPS shall be written in the ______________________ programming language (i.e., full language, not a subset). All deviations to this requirement shall require a waiver and shall be explicitly brought to the attention of the procuring agency.

3.7.2.1.2.2 CPS ORGANIZATION AND PREPARATION.

The CPS shall be organized into computer program/data divisions to provide insight to the development and configuration management of the CPS. There shall be a computer program/data division for each major component subsystem. Each division shall contain those computer program components (CPCs), computer program modules (CPMs), computer program elements (CPEs), and computer data files (CDFs) unique to its major component subsystem. Additional divisions (as necessary) shall be organized for those CPCs, CPMs, CPEs, and CDFs which are common to more than one major component subsystem. Each major component subsystem division shall include subsystem support computer programs necessary to fulfill simulation requirements. The CPS shall ____ ____________________. Any programming language features and structured programming techniques that are used shall not preclude normal updates to the current configuration of computer vendor products as they are released. Computer vendor product updates shall be incorporated into the CPS.

3.7.2.1.2.2.1 TRAINER SUBSYSTEMS SUPPORT COMPUTER PROGRAMS.

Computer programs/data shall be provided to support all on-line and off-line operational requirements of the trainer. Lesson support computer programs and modification support computer programs shall be provided for each major component subsystem as required by this specification. All trainer subsystems support computer programs shall satisfy the following requirements: ____.

3.7.2.1.2.2.2 MAINTENANCE AND TEST COMPUTER PROGRAMS.

Computer programs/data shall be provided to fully test the operation of each major component subsystem in accordance with the requirements of 3.5 and the requirements specified for each major component subsystem. All maintenance and test computer programs shall satisfy the following general requirements: ____.

3.7.2.1.2.2.3 OPERATIONAL READINESS COMPUTER PROGRAMS.

Computer programs and procedures shall be provided to verify that the trainer is operationally ready for training. These programs and procedures shall test the operational readiness of all major component subsystem equipment which operates under computer control. The programs shall generate outputs to all

instruments, controls, lights, and equipment whose operation can be verified with a visual or aural check. The sequence of outputs shall be cyclic, with provisions to stop the sequence at any point. These programs are not intended as calibration programs, but rather as quick system operational checks, and are normally run on a daily basis before the start of the day's training. The time required to complete the operational readiness procedures shall not exceed ______________________________.

3.7.2.1.2.3 CPS DOCUMENTATION.

Documentation shall be provided for the CPS to support its operation, mission support activities, modification support activities, update and revision. Commercially available documentation shall be provided for all unmodified commercial off-the-shelf computer programs and computer program packages used in the CPS. This documentation shall include (as available) programming language manuals, user manuals, maintenance programming manuals, system programming manuals, etc. In addition, all CPS elements shall be documented as specified elsewhere in this specification.

3.7.2.2 COMPUTATIONAL SUBSYSTEM CAPABILITIES.

Unless otherwise explicitly specified, all computational resources employed in the trainer (including embedded processors, firmware, etc.) shall be subject to the requirements of the Computational Subsystem as specified in the following subparagraphs.

3.7.2.2.1 COMPUTATIONAL SUBSYSTEM HARDWARE.

The trainer Computational Subsystem hardware configuration shall fulfill the requirements stated in 3.7.2.1 and elsewhere in this specification and include the equipment specified. This hardware shall satisfy the main computational requirements for all functional subsystems except ______________________.

3.7.2.2.1.1 COMPUTATIONAL EQUIPMENT PERFORMANCE CHARACTERISTICS.

Each computer configuration in the trainer Computational Subsystem shall satisfy the performance requirements and possess the characteristics specified herein.

3.7.2.2.1.1.1 COMPUTATIONAL REQUIREMENTS

In order to meet the programming language requirements (specified in 3.7.2.1), each processing unit (Central Processing Unit or Auxiliary Processing Unit, mini or micro) shall be capable of

performing single-precision and double-precision floating-point arithmetic at rates sufficient to satisfy all computational requirements (both real-time and background processing).

3.7.2.2.1.1.2 INTERRUPT PROVISIONS.

Each computer configuration in the Computational Subsystem shall include a priority interrupt system to support the real-time, event-driven nature of the training device. This system shall (1) provide hardware to distinguish between and identify the sources of simultaneous hardware-generated interrupts, queuing them for service depending on their priorities, and (2) allow computer-program-generated interrupts (e.g., supervisor calls). An interrupt (hardware- or computer-program-generated) shall cause the execution of an interrupt service routine unique to the device or function to which the interrupt pertains.

3.7.2.2.1.1.3 INTERVAL TIMING PROVISIONS.

Each computer configuration in the Computational Subsystem shall include at least one programmable interval timer accessible to each processing unit in the configuration. The interval timers shall be capable of generating both periodic (repetitive) and one-shot (single-occurrence) interrupts. Each interval timer shall be settable and readable under program control, and shall provide interrupts to its processing unit with a resolution of at least ______________________________.

3.7.2.2.1.1.4 REAL-TIME CLOCK.

One or more real-time clocks shall be accessible to each processing unit in the Computational Subsystem to provide operational timing functions. Each real-time clock shall have a range which includes the Julian date and time of day with a resolution of at least _______________. All real-time clocks (if more than one is used) shall be synchronized with one another such that they all reflect the same values.

3.7.2.2.1.1.5 BOOTSTRAP LOADING PROVISIONS.

The Computational Subsystem shall include a hardware bootstrap for loading from the mass storage equipment specified herein (3.7.2.2.1.4.1). The implementation of this requirement

shall be consistent with the requirement for separate loading, initialization, and reinitialization of each computer configuration (3.7.2.1.1.1).

3.7.2.2.1.1.6 POWER FAILURE HARDWARE.

Each computer configuration shall include hardware to provide the power fail capabilities specified herein (3.7.2.2.2.1.1). The hardware shall be designed to prevent damage to the Computational Subsystem in the event of a power failure, surge, or reduction.

3.7.2.2.1.2 INPUT/OUTPUT HARDWARE.

The trainer Computational Subsystem shall be provided with an input/output (I/O) capability sufficient to satisfy all I/O requirements of the computer programs executing upon it. The I/O hardware shall include but not be limited to any computer vendor standard input/output boards and chassis installed in each computer configuration. In addition, spare I/O capacity shall be provided as specified herein (3.7.2.2.1.5.3).

3.7.2.2.1.3 INTERFACE HARDWARE.

Interface hardware (e.g., linkage) shall be provided as necessary to interface the I/O hardware to other trainer hardware controlled by the Computational Subsystem. The interface hardware shall include (but not be limited to) the following types of data conversion hardware which are used in the trainer:

In addition, spare interface hardware shall be provided as specified in 3.7.2.2.1.5.4 herein.

3.7.2.2.1.4 PERIPHERAL EQUIPMENT.

Peripheral equipment shall be provided as specified in the following subparagraphs and functional subsystem sections (as required) of this specification. This equipment shall be sharable (program control switchable) among the Computational Subsystem computer configurations as required by this specification. All peripheral equipment shall be taken into account (i.e., I/O requirements shall be established) for the verification of required spare capabilities (e.g., spare I/O capacity).

3.7.2.2.1.4.1 MASS STORAGE EQUIPMENT.

Mass storage equipment shall be provided as specified in the following subparagraphs. The capability shall be provided to copy between units of different types of mass storage. The mass storage equipment shall be sharable between the computer configurations in the Computational Subsystem which require access to mass storage devices.

3.7.2.2.1.4.1.1 PRIMARY MASS STORAGE.

Mass storage equipment shall be provided and used for storing and loading the operational CPS and for on-line, real-time, and non-real-time data access. The type, size, and complexity of the equipment shall be a function of the Computational Subsystem design, operational load size, and the total system requirements for on-line, real-time and non-real-time information flow and timing.

3.7.2.2.1.4.1.2 SECONDARY MASS STORAGE.

Industry-compatible mass storage equipment shall be provided as secondary mass storage. The equipment shall be used to install CPS changes which are distributed on media transported from the trainer support activities or computer vendors. Selection criteria for secondary mass storage shall include media portability, special support requirements (e.g., media shelf life for archiving data, classified data protection, data transfer rate requirements, data base sizes, etc.), reliability, and maintainability. The unit(s) provided to satisfy the "transport media" requirement shall be accessible (i.e., electrically switchable as a minimum) among all computer configurations in the Computational Subsystem. In the event one type of secondary mass storage is not compatible with all computer configurations, another compatible type shall be provided. If all requirements for secondary mass storage are satisfied by the primary mass storage equipment selected, then no additional equipment need be provided.

3.7.2.2.1.4.2 USER INTERFACE EQUIPMENT.

User interface equipment shall be provided as specified in the following subparagraphs.

3.7.2.2.1.4.2.1 OPERATOR CONSOLES.

One or more operator consoles shall be provided to facilitate operator interaction with the Computational Subsystem. The operator console(s) shall be the primary communication device(s) for the control of the Computational Subsystem. The number and placement of the consoles shall be a function of the Computational Subsystem complexity. The operator console(s) shall satisfy the following requirements: ____________________ ____.

3.7.2.2.1.4.2.2 SUPPORT CONSOLES.

One or more support consoles shall be provided to facilitate interface with all trainer support functions requiring the use of Computational Subsystem resources. The types, quantity, and placement of the consoles shall be a function of the Computational Subsystem complexity, the need for concurrent support activity, and all other support requirements.

3.7.2.2.1.4.3 HARDCOPY EQUIPMENT.

Equipment shall be provided to produce hardcopy output of all data which are displayable on any peripheral display equipment controlled by the Computational Subsystem (i.e., if a graphics console is included in the deliverable peripheral equipment, then a graphics hardcopy capability shall be provided). The selection of hardcopy equipment shall be based on hardcopy throughput requirements (taking into account the number of functions which may require hardcopy capability concurrently), reliability, maintainability, supportability (non-standard hardcopy media such as thermal paper or photo-sensitized paper is not desirable), and life cycle cost. The hardcopy equipment, interface, and computer program(s) driving the equipment shall not introduce any perceptible delays in the operation of any other equipment, subsystems, subsystem features or functions of the trainer.

3.7.2.2.1.4.4 ADDITIONAL PERIPHERAL EQUIPMENT.

In addition to the peripheral equipment specified in the above paragraphs and any other sections of this specification, any additional peripheral equipment necessary to operate or support the trainer shall also be provided. Peripheral equipment not required explicitly by this specification but required to operate or support the trainer shall also be taken into account for the verification of required spare capacities.

3.7.2.2.1.5 COMPUTATIONAL SUBSYSTEM SPARE CAPACITY AND GROWTH CAPABILITY.

Each computer configuration in the Computational Subsystem hardware shall provide spare capacities as specified in the following subparagraphs. The capability shall be provided to verify the spare capacities specified. In addition, the Computational Subsystem shall be expandable in a fashion that does not cause existing equipment to become obsolete.

3.7.2.2.1.5.1 SPARE PROCESSING TIME.

Spare processing time shall be provided. The spare processing time requirement shall apply separately to each processing unit (i.e., CPU and APU) in each computer configuration. A frame shall consist of a fixed scheduling of synchronous computer program components. The duration of each frame (available frame time) shall not exceed the period (1/f) of the maximum computer program component iteration rate. The processing time associated with a frame shall include processing time dedicated to background processing used in the normal support of the trainer and shall take into account memory bus connections between processors and I/O equipment performing direct memory access.

a. As a minimum, ________________________ percent of the available frame time shall be provided as spare processing time to provide a buffer between the worst-case (maximum) frame execution time and a frame overrun (when the execution time for a frame exceeds the available frame time). The worst-case frame time shall be the maximum frame time observed with the trainer operating under heavily loaded conditions (i.e., all concurrent support activities operational and the maximum level of simulation being performed).

b. In addition, ________________________ percent of the available frame time shall be provided as spare processing time to allow for changing mission requirements over the life cycle of the trainer.

c. Therefore, a total of __________________ percent of the available frame time shall be provided as spare processing time. This total spare is the spare which shall be verified.

3.7.2.2.1.5.2 SPARE MEMORY OR MEMORY EXPANSION CAPABILITY.

____________________ percent usable spare memory or memory expansion capability shall be provided to allow for changing lesson requirements over the life cycle of the trainer. This requirement shall apply separately to each type of memory (static, dynamic, etc.) in each computer configuration, and also to both

common and private memory. The decision to provide spare, expansion capability, or a combination of both shall be based on life cycle cost (to the best extent possible).

3.7.2.2.1.5.3 INPUT/OUTPUT EXPANSION.

The total number of I/O channels in each computer configuration shall be increasable by ______________ percent (i.e., spare slots for I/O boards shall be provided). The available information transfer capacity shall be increasable by the same percentage without degrading the performance of the trainer. The inclusion of spare I/O channels with the trainer (or a combination of spare and expansion) is allowable if it is more cost effective over the life-cycle of the trainer. However, the spare I/O channels must be evenly distributed across all computer configurations and I/O channel types.

3.7.2.2.1.5.4 INTERFACE HARDWARE SPARE CAPACITY.

__________________ percent of each type of interface hardware shall be provided as spare. This spare interface hardware shall be usable without degrading the performance of the trainer (i.e., the Computational Subsystem shall be capable of driving both the used and spare interface hardware at their fully loaded capacities). The spare capacity shall be evenly distributed across each interface hardware type and shall be easily accessible to any computer configuration in the Computational Subsystem.

3.7.2.2.1.5.5 PRIMARY MASS STORAGE SPARE AND GROWTH.

a. Each unit of primary mass storage equipment shall have an on-line, spare storage capacity that is at least ____________ percent of its total capacity.

b. The on-line storage capacity provided for primary mass storage shall be increasable by _____________ percent (i.e., the addition of units shall be provided for).

3.7.2.2.1.5.6 PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS.

The Computational Subsystem shall operate within the total trainer requirements, in accordance with the environmental characteristics of this specification. The Computational Subsystem shall operate with the power available at the installation site. Means shall be provided to eliminate transients, pulses, and other electrical noise that could cause Computational Subsystem malfunctions.

3.7.2.2.2 COMPUTATIONAL SUBSYSTEM COMPUTER PROGRAMS/DATA.

Computer programs/data shall be provided for the Computational Subsystem which support all modes of trainer operation (i.e.,

training, student evaluation, support, and maintenance and test). These programs shall perform all computations and input/output functions at rates sufficient to satisfy all requirements in this specification. Commercially available computer programs/data shall be used to satisfy these requirements wherever possible. A standard computer vendor operating system shall be provided and used in each general-purpose digital computer in the Computational Subsystem during all modes of trainer operation. The operating system (OS) configuration used while training is in progress shall provide for the concurrent execution of background computer programs. This OS (and all configurations thereof) shall be at the latest vendor revision level.

3.7.2.2.2.1 SUPERVISOR/EXECUTIVE COMPUTER PROGRAM.

Computer programs shall be designed and provided which shall maintain and direct the problem flow and establish priority controls over all trainer operational computer programs/data. These programs shall provide all functions necessary to control the multiple iteration rate task structure and shall provide frame and cycle synchronization, at fixed rates and durations, such that spare processing time can be measured.

3.7.2.2.2.1.1 POWER FAILURE COMPUTER PROGRAMS.

Computer programs/data shall be developed to provide for the orderly shutdown and restart of the Computational Subsystem in the event of trainer power loss, reduction, or interruption. The programs shall cause the status of the trainer to be saved on a mass storage device. The status saved shall include all data and other parameters (i.e., registers, stacks, tables, etc.) necessary to restore the configuration of the Computational Subsystem and associated trainer hardware to the configuration which existed within ______________________ seconds or for the lesson step (whichever is applicable). These programs shall operate with the power failure hardware provided.

3.7.2.2.2.1.2 DEBUG COMPUTER PROGRAMS.

Computer programs/data shall be provided to assist maintenance personnel in debugging CPS computer programs and Computational Subsystems hardware. These programs shall operate in real time during normal trainer operation. User interaction with these programs shall occur through a support console. These programs shall satisfy the following requirements: ______________________
____.

3.7.2.2.2.2 INPUT/OUTPUT COMPUTER PROGRAMS.

Computer programs/data shall be provided for control of inputs from and outputs to all peripheral equipment and interface hardware controlled by the Computational Subsystem during all modes of trainer operation.

3.7.2.2.2.3 COMPUTATIONAL SUBSYSTEM MISSION SUPPORT COMPUTER PROGRAMS/DATA.

Computer programs/data shall be provided to support the total on-line and off-line operational requirements of the trainer. All programs provided shall satisfy the general requirements for support programs specified in 3.7.2.1.2.2.1.

3.7.2.2.2.3.1 MASS STORAGE COPY/COMPARATOR PROGRAMS.

Computer programs shall be provided which satisfy the following functional requirements between all units (e.g., drives, transports) of similar and dissimilar mass storage in both the primary and secondary mass storage systems (e.g., disk-to-disk, disk-to-tape, tape-to-tape, etc.): ______________________________
____.
These programs shall be operable through an operator or support console and shall allow the error output to be optionally directed to hardcopy.

3.7.2.2.2.3.2 COMPUTATIONAL SUBSYSTEM MISSION SUPPORT DOCUMENTATION.

Documentation shall be provided for the mission support of the trainer Computational Subsystem. Included shall be user and/or operation manuals for all hardware in the Computational Subsystem and for all computer programs/data executing or designed to execute on Computational Subsystem hardware. Commercial-format user manuals and/or operation manuals may be provided for standard commercial products. In addition, a system user's manual (sometimes referred to as a system user's guide) shall be provided which outlines the procedures necessary for the daily operation and lesson support of the trainer and provides references as necessary to the other user/operation manuals.

3.7.2.2.2.4 COMPUTATIONAL SUBSYSTEM MAINTENANCE AND TEST COMPUTER PROGRAMS.

Computer programs/data shall be developed and provided to fully test the operation of the Computational Subsystem and associated equipment in accordance with the requirements specified herein.

These programs shall be designed to execute on the deliverable computer configuration(s) and shall be controllable with a single support console. Hardcopy of the input and output parameters shall be an option at execution time.

3.7.2.2.2.4.1 COMPUTER EQUIPMENT DIAGNOSTIC COMPUTER PROGRAMS.

A complete set of diagnostic programs shall be provided to isolate equipment failures in the Computational Subsystem. Except for the portions of test that check whether or not inputs can be received from and outputs can be transmitted to the equipment in question, all diagnostics shall be fully automatic. This means that once the user has loaded the diagnostic and set up initial conditions, the program will automatically generate error indications (if any) on the console and hardcopy device. These programs shall be capable of automatic execution as a total package and as individual diagnostic checks. The diagnostics shall check each computer configuration and its options, and all memory units, peripheral units, and input/output units. Programs shall also be included for computer equipment embedded in and dedicated to subsystem processing or any other special processors as defined herein.

3.7.2.2.2.4.2 INTERFACE HARDWARE DIAGNOSTIC COMPUTER PROGRAMS.

Computer programs/data shall be provided to perform functional checkout of all trainer interface hardware controlled by the Computational Subsystem at performance rates and with test values characteristic of real-time operation. This shall include the checkout of instructor/operator station interfaces, I/O controllers, multiplexers, demultiplexers, signal conversion equipment, special interface equipment, and any other interface hardware that is functionally testable with computer programs/data. The programs shall provide fault isolation and identification to the appropriate level. Trainer equipment normally driven by this interface hardware shall be automatically disconnected during the performance of these tests when necessary to prevent equipment damage. All disconnection and reconnection shall be accomplished under computer control. The programs shall perform automatic range checking of the user inputs to prevent equipment damage caused by out-of-range values. The programs shall also perform the tests and meet the requirements specified in the following subparagraphs for the specified types of interface hardware. Testing shall be performed in a closed-loop fashion. Upon detecting a malfunction, the programs shall automatically indicate the failing hardware on the console and in hardcopy.

3.7.2.2.2.4.2.1 DISCRETE INPUT AND OUTPUT TESTS.

The interface hardware diagnostic computer programs/data shall check the proper functioning of all the discrete input and output channels, including spares, in a closed-loop fashion.

3.7.2.2.2.4.2.2 ANALOG INPUT AND OUTPUT TESTS.

Analog input and output tests shall be performed which exercise all of the analog interface hardware through its full range of operation. This shall be accomplished in a closed-loop fashion. The tests shall be designed such that accuracy criteria have defaults or can be overridden by the user. Tests shall include a dynamic test which enables the user to specify (on the console) the amplitude of a test signal to a specified channel.

3.7.2.2.2.4.3 TRAINER EQUIPMENT TEST COMPUTER PROGRAMS.

Computer programs/data shall be provided to check the proper functioning of all remaining equipment in the trainer which is controlled by the Computational Subsystem that cannot be tested in a closed-loop fashion.

3.7.2.2.2.4.4 CALIBRATION TEST COMPUTER PROGRAMS.

Computer programs/data shall be provided to enable all instruments and controls driven by the Computational Subsystem to be (1) calibrated and (2) tested to verify calibration. The programs shall allow both static and dynamic test signals to be applied to each instrument (as appropriate) to verify the instrument's accuracy, dynamic range, and general ability to model the performance of its real-world counterpart (e.g., lack of perceptible stepping, etc.)

3.7.2.2.2.4.5 SPARE CAPACITY VERIFICATION COMPUTER PROGRAMS.

Computer programs/data to verify the specified spare capacities (3.7.2.2.1.5) shall be provided. Optional hardcopy output shall be selectable when exercising these programs.

3.7.2.2.2.4.5.1 SPARE PROCESSING TIME VERIFICATION COMPUTER PROGRAMS.

Computer programs shall be provided and used to measure the actual frame and cycle time durations (execution times) on each computer configuration in the Computational Subsystem during the execution of the trainer operational computer programs. These

programs shall be a permanent part of the real-time load and shall be selectable and deselectable without interruption of real-time trainer operation. Control of and interface with these programs shall be through a support console. The output to be computed and displayed shall include: ________________________

____.

3.7.2.2.2.4.5.2 SPARE MEMORY/ON-LINE PRIMARY MASS STORAGE VERIFICATION COMPUTER PROGRAMS.

Computer programs shall be provided to verify the spare capacities specified for memory (3.7.2.2.1.5.2) and on-line primary mass storage (3.7.2.2.1.5.5). These programs shall provide the data from which calculations will be made to verify compliance. The spare memory data shall be obtained from the trainer operational computer program configuration which produces the maximum memory utilization. Computer vendor operating system built-in functions or utilities may be used if all requirements are satisfied.

3.7.2.2.2.4.6 COMPUTATIONAL SUBSYSTEM MAINTENANCE AND TEST DOCUMENTATION.

Documentation shall be provided to support the maintenance and test of the trainer. The documentation shall include (1) one or more test plans which outline the testing philosophy and approaches for all trainer hardware and computer programs/data, (2) a detailed set of test procedures which provide the information necessary to accomplish the operational testing of the entire trainer, and (3) maintenance manuals for all trainer hardware.

3.7.2.3 TRAINER SUPPORT SYSTEMS.

The Trainer Support Subsystem (TSS) shall include all hardware, computer programs/data, and documentation necessary to provide for the modification support of the trainer. The TSS shall be

____.

3.7.2.3.1 MODIFICATION SUPPORT HARDWARE.

Hardware shall be provided to satisfy all modification support functional requirements specified herein. ________________________

________________________.

3.7.2.3.1.1 TSS COMPUTATIONAL HARDWARE.

Modification support computational requirements shall be satisfied by ____.

All TSS computational hardware shall be subject to the general system requirements for Computational System hardware specified in 3.7.2.1.1 and 3.7.2.1.1.1.

3.7.2.3.1.1.1 TSS COMPUTER EQUIPMENT PERFORMANCE.

The configuration of computer equipment selected for the TSS shall be capable of processing all modification support computer programs at speeds sufficient to satisfy all modification support functional requirements. All computer configurations shall include spare capacities in accordance with 3.7.2.1.1 and the requirements of this subsystem.

3.7.2.3.1.2 TSS PERIPHERAL EQUIPMENT.

Peripheral equipment shall be provided as specified in the following subparagraphs. This equipment shall be sharable (program control switchable) among the TSS computer configurations as required. All peripheral equipment shall be taken into account for the verification of required spare capacities. The operational environment shall also be taken into account for the placement of the equipment in the facility where the TSS is located.

3.7.2.3.1.2.1 TSS MASS STORAGE EQUIPMENT.

Mass storage equipment shall be provided for the TSS which shall be compatible with the secondary mass storage of the Computational Subsystem. Additional mass storage equipment shall be provided as necessary to provide for the efficient implementation of all modification support activities required for the TSS.

3.7.2.3.1.2.2 MODIFICATION SUPPORT CONSOLES.

One or more support consoles shall be provided to facilitate user interface with all trainer modification support functions requiring the use of TSS computational hardware. The types, quantity, and placement of the consoles shall be a function of the need for concurrent modification support activity and all other modification support requirements.

3.7.2.3.1.2.3 TSS HARDCOPY EQUIPMENT.

Equipment shall be provided to produce hardcopy output of all data which is displayable on any peripheral display equipment controlled by the TSS computational hardware. The selection of hardcopy equipment shall be based on hardcopy throughput requirements, reliability, maintainability, supportability, and life cycle cost.

3.7.2.3.1.2.4 ADDITIONAL MODIFICATION SUPPORT PERIPHERAL EQUIPMENT.

In addition to the modification support peripheral equipment specified above, any additional modification support peripheral equipment necessary to support the modification of the trainer shall be provided. Included shall be all equipment necessary to support all digital storage technologies used in the trainer i.e., read-only memory (ROM), programmable read-only memory (PROM), field programmable logic arrays (FPLAs), etc. The additional equipment shall be configured to operate directly or in conjunction with the TSS computational hardware as necessary and shall also be taken into account for the verification of required spare capacities.

3.7.2.3.1.3 TSS SPARE CAPACITY AND GROWTH CAPABILITY.

The modification support hardware shall provide the spare capacities specified in the following subparagraphs. The capability shall be provided to verify the spare capacities specified. In addition, growth capability shall be provided as specified.

3.7.2.3.1.3.1 MEMORY SPARE OR GROWTH.

_________________________ percent usable spare memory or memory expansion capability shall be provided to allow for changing modification support requirements over the life cycle of the trainer. This requirement shall apply separately to each type of memory in each computer configuration in the TSS computational hardware. The decision to provide spare, expansion capability, or a combination of both shall be based on life-cycle cost.

3.7.2.3.1.3.2 MASS STORAGE SPARE AND GROWTH.

a. Each unit of mass storage equipment which is used in a random access mode of operation shall have an on-line, spare storage capacity that is at least _______________ percent of its total capacity.

b. The total on-line storage capacity of the mass storage equipment shall be increased by _____________________________ percent (i.e., the addition of units shall be provided for).

3.7.2.3.1.3.3 I/O EXPANSION.

The I/O capacity of the TSS computational hardware in terms of the addition of peripheral equipment (consoles, mass storage, etc.) shall be increasable by _________________________ percent.

3.7.2.3.1.4 TSS PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS.

The TSS shall operate within the total trainer requirements, in accordance with the environmental characteristics of this specification. The TSS shall operate with the power available at the installation site. Means shall be provided to eliminate transients, pulses, and other electrical noise that could cause TSS malfunctions.

3.7.2.3.2 TSS MAINTENANCE AND TEST COMPUTER PROGRAMS.

Computer programs/data shall be developed and provided to fully test the operation of the TSS and associated equipment in accordance with the requirements specified herein. These programs shall be designed to execute on the deliverable TSS computer configuration(s) and shall be controllable with a single modification support console. Hardcopy of the input and output parameters shall be an option at execution time.

3.7.2.3.2.1 TSS COMPUTER EQUIPMENT DIAGNOSTIC COMPUTER PROGRAMS.

A complete set of diagnostic programs shall be provided to isolate equipment failures in the TSS. Except for the portions of test that check whether or not inputs can be received from and outputs can be transmitted to the equipment in question, all diagnostics shall be fully automatic. This means that once the user has loaded the diagnostic and set-up initial conditions, the program will automatically generate error indications (if any) on the console and hardcopy device. These programs shall be capable of automatic execution as a total package and as individual diagnostic checks. The diagnostics shall check each computer configuration and its options, and all memory units, peripheral units, and input/output units in the TSS.

3.7.2.3.2.2 TSS EQUIPMENT TEST COMPUTER PROGRAMS.

Computer programs/data shall be provided to check the proper functioning of all remaining TSS equipment and equipment controlled by TSS computational hardware.

3.7.2.3.2.3 SPARE CAPACITY VERIFICATION COMPUTER PROGRAMS.

Computer programs/data shall be provided to verify the spare capacities specified for the modification support hardware. Optional hardcopy output shall be selectable when executing each program.

3.7.2.3.2.3.1 SPARE MEMORY AND MASS STORAGE VERIFICATION COMPUTER PROGRAMS.

Computer programs shall be provided to verify the spare capacities specified for memory and mass storage. These programs

shall provide the data from which calculations will be made to verify compliance. The spare memory data shall be obtained from the configuration of modification support activity which produces the maximum memory utilization. Computer vendor operating system built-in functions or utilities may be used if all requirements are satisfied.

3.7.2.3.3 MODIFICATION SUPPORT COMPUTER PROGRAMS/DATA.

Computer programs/data shall be provided to support the modification of the Computational System and the interfaced major component subsystems which result from changes to the simulated equipment, air-vehicle, or crew stations (e.g., addition, deletion, or modification of equipment items, systems, or airborne digital multiplexed data busses, instrument changes, or other system modifications which force changes to be made to the trainer interface hardware). Computer vendor-supplied, commercial, off-the-shelf (unmodified) computer programs shall be provided wherever possible or required.

3.7.2.3.3.1 TSS OPERATING SYSTEM.

A standard computer vendor operating system (OS) shall be provided for each general-purpose digital computer in the TSS computational hardware. The OS must support multi-terminal interactive and batch processing modes of operation. The TSS OS may be the same as that provided for the Computational Subsystem if all modification support requirements are satisfied.

3.7.2.3.3.2 COMPILERS/ASSEMBLERS.

All compilers and assemblers used in the generation of the CPS shall be provided. The use of compilers and assemblers in the generation of the CPS shall be consistent with the programming language requirements of this specification. In addition, any pre-compilers or source-code processors whose output is used as input to the compilers or assemblers shall be provided. Compilers and/or assemblers shall be provided for each type of computer used in the Computational System.

3.7.2.3.3.3 LOADERS.

All loaders, linking loaders, task builders, and any other computer programs used to establish the operational CPS configuration shall be provided. Standard computer vendor, off-the-shelf, commercial computer programs shall be used to satisfy this requirement to the maximum extent possible.

3.7.2.3.3.4 DATABASE MANAGEMENT COMPUTER PROGRAMS.

Computer programs/data shall be provided and used to develop and modify data bases which are directly related to Computational System hardware or other trainer hardware controlled by the Computational System (e.g., interface hardware address or configuration tables, mapping tables or data, etc.). This shall include the modification of data bases delivered to fulfill the functional requirements of the trainer subsystems (e.g., visual data base, radar landmass data base, PWT data, etc.)

3.7.2.3.3.5 TEXT EDITORS.

Computer programs shall be provided to allow computer program source-code to be easily altered or created. The programs shall utilize modification support consoles for user input and output. The programs shall allow the modification of all source code provided with the trainer (i.e., the modification of source code for each type of computer). Standard computer vendor, off-the-shelf, commercial computer programs shall be used to satisfy this requirement to the maximum extent possible.

3.7.2.3.3.6 DEVELOPMENT TOOLS.

All computer program development tools used in the development of the CPS shall be provided. Examples of such computer programs are execution flow tracers, emulators, syntax analyzers, and debug computer programs. The programs shall utilize modification support consoles for user input and output.

3.7.2.3.3.7 TSS MASS STORAGE COPY/COMPARATOR COMPUTER PROGRAMS.

Computer programs shall be provided which shall satisfy the functional requirements specified for and be compatible with the Computational Subsystem mass storage copy/comparator computer programs (3.7.2.2.2.3.1) for all types of mass storage used in the TSS. The programs shall utilize a modification support console for user input and output. Hardcopy of all console output shall be selectable by the user.

3.7.2.3.4 MODIFICATION SUPPORT DOCUMENTATION.

Documentation shall be provided for the modification support of the trainer. This documentation shall contain both the system level (preliminary) and detailed design for all modifiable portions of the trainer. This documentation shall be provided for both hardware and computer programs/data as necessary. Commercial-format documentation may be provided for commercial off-the-shelf (unmodified) hardware and computer programs if the functioning of the commercial product is not integral to the design of the real-time system simulation.

3.7.2.3.4.1 HARDWARE MODIFICATION SUPPORT DOCUMENTATION.

The modification support documentation for trainer hardware shall include a product specification which describes the delivered trainer configuration, detailed subsystem product specifications as necessary, and any other documentation such as schematic diagrams, drawings, interface diagrams, etc., which would be necessary or helpful in the modification of any trainer hardware.

3.7.2.3.4.2 CPS MODIFICATION SUPPORT DOCUMENTATION.

Documentation shall be provided for all elements of the CPS to support its modification. Included in the documentation shall be (1) a computer program development plan which establishes and documents the planning, procedures, and design standards used during the development of the CPS and which should continue to be used throughout the trainer's life cycle for its modification support (to ensure consistency); (2) a computer program development specification which defines the system-level design of the CPS and defines all hardware interfaces; (3) one or more computer program product specifications which describe the detailed design of all computer programs used in the real-time simulation of any systems and those computer programs used to interface with the trainer hardware or commercial computer programs. For those commercial computer programs not subject to item (3) above, commercial-format documentation shall be provided. Source code shall be provided for all computer programs except those commercial computer programs for which source code is not economically available. For those computer programs for which source code is not delivered, a waiver must be requested identifying the problem and the reasons for the waiver. However, the functional design of these programs shall be documented to a level sufficient to allow a replacement to be developed, supplementing the commercial documentation as necessary.

3.7.2.3.5 SUBSYSTEM-UNIQUE MODIFICATION SUPPORT REQUIREMENTS.

The TSS shall provide hardware and computer programs as necessary to meet the requirements defined in the following subparagraphs for the modification support of the trainer subsystems.

3.7.2.3.5.1 COMPUTATIONAL SUBSYSTEM MODIFICATION SUPPORT.

The following modification support requirements shall be met for the Computational Subsystem.

3.7.2.3.5.1.1 CPS GENERATION COMPUTER PROGRAMS.

Computer programs/data shall be provided to perform a complete software object-code generation ("cold-start") of the operational CPS. This shall include the automatic compilation/assembly of all available source code into CPEs, the generation of all CDPs, and the combination of the CPEs and CDFs into CPMs and CPCs and tasks ready for execution on the Computational Subsystem. The programs shall be designed to require a minimum of user input and shall allow for the optional generation of hardcopy of all console output and all listing files generated by the compilers, assemblers, or loaders utilized in the process.

3.7.3 OTHER MAJOR COMPONENTS.

____
____.

3.8 PRECEDENCE.

a. The precedence of the requirements specified herein shall be as follows: ____.

b. The precedence of referenced documents shall be in accordance with subparagraph 2.1 of this specification.

4.0 QUALITY ASSURANCE PROGRAM.

4.1 QUALITY ASSURANCE PROGRAM, GENERAL.

____
____.

4.1.1 RESPONSIBILITY FOR TESTS.

a. All tests shall be conducted by: ____.

b. The conditions of testing shall be as follows: ____.

4.1.1.1 TEST SCHEDULE.

The test schedule shall be as follows: ____.

4.1.2 SPECIAL TESTS/SPECIFIC TESTS.

Special test and specific test requirements shall be as follows:

a. Operational Tests. An operational test shall be performed to assess the trainer's ability to complete its training mission satisfactorily, as defined herein and by the ISD (Instructional System Development) analysis (see ISD-Derived Training Equipment Design Specification for the results of the ISD analysis). During the operational test, the training exercises shall be conducted just as they would be in the training environment. The responses of the trainer shall be verified against the available T.O.s, the results of the ISD analysis, and the baseline data provided at CDR (Critical Design Review). The Air Force shall be given the opportunity to test the trainer in the free-play mode. If the training exercises permit different student paths through the completion of a given exercise, the representative paths shall be verified. During the operational test, unlikely responses (responses which untrained students might make) shall be tried and their consequences recorded. If the trainer is designed to allow instructors the opportunity to create new training exercises, part of the operational test shall consist of creating at least one new exercise.

   Other operational test requirements shall be as follows: ____.

b. Reliability Tests. The reliability test requirements shall be as follows: ____.

c. Maintainability Tests. The maintainability test requirements shall be as follows: ____.

d. Software (computer program) Diagnostic Tests. The software test requirements shall be as follows: ____.

e. Human Factors Compliance Tests. The human factors compliance test requirements shall be as follows: ____.

f. Other tests: ____.

4.2 VERIFICATION CROSS-REFERENCE INDEX.

Verification Cross-Reference Index: Verification shall be accomplished by inspection, analysis, demonstration, or test, or a combination thereof, as defined below:

a. Inspection. Inspection is defined as a visual verification that the unit as manufactured conforms to the documentation to which it was designed.

b. Analysis. Analysis is defined as verification that a specification requirement has been met by technical evaluation of equations, charts, reduced data and/or representative data displays.

c. Demonstration. Demonstration is a method of verification denoting the qualitative or quantitative determination of the properties and parameters (or components thereof) by means which do not necessarily require the use of laboratory equipment, procedures, items, or services to verify conformance to specified requirements.

d. Test. Test is defined as verification that a specification's requirement is met by thorough exercising of the applicable training equipment under appropriate conditions in accordance with applicable performance checkout and test procedures. Testing normally requires instrumentation.

The following table establishes the method of verification/qualification to be applied: ______________________
____
__________________________.

5.0 PREPARATION FOR DELIVERY.

Unless otherwise specified in the contract or order, preparation for delivery of the maintenance trainer shall be: ____________
____

6.0 NOTES.

____
____.

SECTION III

MODEL SPECIFICATION HANDBOOK

Introduction: Rationale and Guidance, Performance Parameters, Background and Sources, and Lessons Learned

General

This Handbook contains the instructions that are necessary to tailor the paragraphs and subparagraphs of the Prime Item Development Specification for Maintenance Training Simulators (hereafter referred to as the Prime Item Development Specification) for a specific application. The Prime Item Development Specification is contained in Section II of this paper. The Prime Item Development Specification was designed to be a generic or model specification; i.e., it can be used to specify the training and engineering requirements of both I- and O-level maintenance trainers. Since the specification is generic (can be used to describe the requirements of various types of maintenance trainers), the preparer will need some guidance in completing the specification. This Handbook was developed to provide this guidance.

Purpose

The generic Prime Item Development Specification for maintenance trainers contains two types of paragraph and subparagraph formats. There are those paragraphs and subparagraphs which should be incorporated into all maintenance trainer specifications (i.e., are common and appropriate (applicable) to all types of maintenance trainers). These paragraphs and subparagraphs contain no blanks to be completed by the preparer. The second type of paragraph and subparagraph format contain blanks to be completed by the preparer. It is the blanks and the information that is inserted in the blanks that allows the preparer to tailor the Prime Item Development Specification to his or her specific needs and situation. This Handbook provides guidance in:

1. Determining which paragraphs and subparagraphs should be incorporated into the prepared specification. This selection is based upon the type of trainer being described and the specific situation surrounding the preparation of the specification.

2. Determining the specific content to be inserted into the blanks; i.e., this Handbook provides instructions concerning what information (content) is to be placed in

blanks. Not only is the type of information (content) discussed, but the Handbook also:

a. Provides suggested wording for the content that is to be inserted in the blanks. Typically, the suggested wording originates from:

   - Existing Military Standards and regulations.

   - Information supplied by Instructional System Development (ISD) analysts via the ISD-Based Maintenance Training Equipment Design Specification. The ISD-Based Maintenance Training Equipment Design Specification is a specification containing training requirements derived from the application of the ISD approach to designing instruction.

   - Previous maintenance trainer specifications (e.g., the F-16 maintenance trainer specifications).

b. If wording is not suggested, then the Handbook provides a list of sources that should be consulted before the preparer completes the blanks. Typically these sources are Military Standards and Regulations.

c. Provides cautions to be exercised when completing the blanks. Typically these cautions originate from the experiences gained during other maintenance trainer acquisition projects. That is, the Air Force has learned certain lessons (both good and bad experiences) in the acquisition of other maintenance trainers. This Handbook discusses these lessons learned when they are appropriate to the specification of particular requirements. In this way, it is possible for the preparer to profit from the experiences of others.

Use

The Prime Item Development Specification and this Handbook are both part of a system for preparing a maintenance trainer procurement specification. A brief review of this system is included here to orient the preparer.

A maintenance trainer procurement specification contains both training requirements and engineering requirements. Training requirements include such requirements as the learning objectives to be

achieved and/or practiced on the intended trainer, a description of how the intended trainer will be used by the instructor(s) to achieve or attain the specified learning objectives, a description of the functional and physical characteristics of the components to be simulated (i.e., the specific fidelity levels of the components to be simulated), a description of the kind of instructional features that the intended trainer must possess to effectively achieve the stated learning objectives, and a description of the training configuration of the trainer. Engineering requirements include such items as Maintainability Requirements, Reliability Requirements, Availability Requirements, Safety Requirements, Electromagnetic Compatibility Requirements, etc. Typically, the training requirements are identified by an ISD analyst following the Air Force ISD procedure. Engineering requirements are, typically, the responsibility of the engineer who is assigned to the System Program Office (SPO).

The system developed for preparing a maintenance trainer procurement specification consists of the following general steps:

1. ISD analysts perform an ISD analysis. Procedures for performing the ISD analysis are documented in several publications.[3] These procedures allow the analyst to determine if a maintenance trainer is needed and provide guidance in determining the characteristics of the trainer (e.g., the level of fidelity of the components to be simulated).

2. Either after or during the ISD analysis, the ISD analyst prepares an ISD-Based Training Equipment Design Specification. This document is a trainer specification containing all the necessary training requirements for the intended trainer. The ISD-Based Training Equipment Design Specification is submitted to the SPO.

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[3]The following two documents are cited as examples:

Department of the Air Force. Handbook for designers of instructional system. Volumes I-V. Washington, DC: Author, Headquarters U.S. Air Force 15 July 1978. AFP 50-58. Hereafter referred to as AFP 50-58.

Hritz, Rohn J., Harris, Hobart J., Smith, Jennifer, A., & Purifoy, George, R. Jr. Maintenance training simulator design and acquisition: Handbook of ISD procedures for design and documentation. AFHRL-TP-81-51. Lowry Air Force Base, Colorado: Logistics and Technical Training Division. 1982. Hereafter referred to as Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation.

3. At the SPO, the training requirements in the ISD-Based Training Equipment Design Specification are reviewed and verified and the engineering requirements are added. Both the training requirements and the engineering requirements are then incorporated into a procurement specification (a specification which is distributed to contractors and vendors for bids). A generic procurement specification is what appears in Section II of this document. This Handbook provides guidance on how to prepare this procurement specification; i.e., it provides guidance on how the procurement specification preparer uses the ISD-Based Training Equipment Design Specification and how Military Standards and regulations are used to establish and state engineering requirements.

Notice the developed procedure involves two specifications - one prepared by the ISD analysts stating only training requirements and the other stating both training and engineering requirements (the procurement specification). The concept of two specifications was developed for several reasons:

1. The concept of two specifications was viewed as a vehicle for increasing communications between ISD analysts and SPO engineers. The ISD-Based Training Equipment Design Specification is a way to assure that training requirements are not misinterpreted or misunderstood (and, thus, are stated properly in the procurement specification).

2. Dual specifications facilitate the review and verification of the training requirements.

3. Dual specifications help to put both the training requirements and the engineering requirements in their proper perspective.

It should be stressed that the completion of the Prime Item Development Specification (the procurement specification) and the use of this Handbook are predicated on:

1. The performance of an ISD analysis; i.e., an ISD analysis must be completed or be in process.

2. The analyst's completing the ISD-Based Training Equipment Design Specification, the document that provides the sources for all the training requirements to be included in the procurement specification. It should be noted that many of the paragraphs and subparagraphs of the ISD-Based Training Equipment Design

Specification can be directly inserted into the procurement specification (after they are reviewed, verified, and perhaps, modified by the procurement specification preparer).

If the two stipulations stated above are not satisfied, then it will be difficult to complete the Prime Item Development Specifications. Often these stipulations are not satisfied when the procurement specification is being prepared:

1. Often an ISD analysis is not completed or planned. If an ISD analysis is not completed, then two options are available.

   a. The procurement specification can make provisions for the contractor or vendor to perform the ISD analysis (or part of the ISD analysis--that part which has not been completed). That is, the procurement specification must specify the requirements (and outputs) of the contractor performed ISD analysis. Currently, the generic specification makes no provisions for this situation. (Note: Air Force regulations dictate that an ISD analysis must be performed.) This means, then, that part of the procurement specification would contain the requirements for performing the ISD analysis. If this option is selected, the preparer should read <u>Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation</u>. This document describes how the ISD analysis should be performed as well as what output is desired. This document could be used to establish the performance requirements of the contractor's ISD analysis. If the ISD analysis is started but not complete, it is still possible to use the ISD-Based Training Equipment Design Specification as a source for the training requirements; i.e., the ISD specification was designed to be completed as the ISD process is occurring. Certain paragraphs and subparagraphs of that document can be completed while other requirements are being established. However, it should be known that the ISD process is iterative, and training requirements established early in the ISD process can be changed as the ISD process progresses. That is, at different stages in the ISD process, it is possible to have different degrees of detail on all the training requirements. Thus, the procurement specification can be updated as the ISD analysis is being completed.

b. The preparation of the Prime Item Development Specification could be postponed until the training requirements are established either via a contract or by personnel within the Air Force (e.g., the 3306th Test and Evaluation Squadron, Edwards Air Force Base, California). However, the acquisition cycle often prohibits this luxury.

2. It is quite possible that the ISD analysis will be performed differently than the recommended procedures specified in the ISD Handbook. If this is the case, the Prime Item Development Specification preparer may not have the ISD-Based Training Equipment Design Specification. In this event, the Prime Item Development Specification preparer should:

   a. Request that the ISD analyst prepare and submit an ISD-Based Training Equipment Design Specification.

   b. Obtain what information is available from the ISD analyst and complete the ISD-Based Training Equipment Design Specification.

In general, the preparer of the Prime Item Development Specification should perform the following activities when completing the Prime Item Development Specification:

1. Review the completed ISD-Based Training Equipment Design Specification, supplied by the ISD analysts. If an ISD analysis will not be completed, then the preparer must determine if the contractor or vendor should be given the responsibility to complete the ISD analysis under contract. If yes, then the procurement specification must make this requirement clear.

2. Review the Prime Item Development Specification (see Section II of this paper). The review will familiarize the preparer with the requirements which must be specified, as well as with the locations within the specification where requirements are located.

3. The preparer should read, for each paragraph and subparagraph of the Prime Item Development Specification, the corresponding Rationale and Guidance section of this Handbook. The Rationale and Guidance sections of the Handbook provide sufficient information for the preparer to determine if the specific paragraph or subparagraph should be included in the Prime Item Development Specification being prepared.

To assist the preparer in keeping track of which paragraphs and subparagraphs should be contained in the current application, a reproducible worksheet is provided in Appendix C. The preparer should obtain photocopies of the worksheet in Appendix C (for future specification preparation activities). The worksheet contains, basically, six columns. The first column contains the paragraph or subparagraph numerical identification, while the second contains its title. The worksheet has all the paragraphs and subparagraphs contained in the generic Prime Item Development Specification. The third column indicates whether each paragraph contains blank(s). As the preparer makes the decision concerning inclusion of the paragraph or subparagraph in the current application, he or she should record the decision in the fourth column of the worksheet. The fifth column indicates the Handbook page number for each paragraph. The sixth column is reserved for any comments or notes the preparer wants to make about each paragraph or subparagraph; e.g., a note indicating a source document, or words that might be inserted in the blanks, or a way to record which paragraphs are completed.

Once the worksheet is completed (as the preparer reads the Rationale and Guidance section for each paragraph or subparagraph), the worksheet will serve as a vehicle for informing the preparer what work was done and what work remains to be accomplished.

4. For each of those paragraphs and subparagraphs that have a check under the "Yes, to be included," the preparer should read the Performance Parameters, Background and Sources, and Lessons Learned sections of this Handbook (each paragraph and subparagraph has each of these sections). These sections provide the guidance necessary to complete the paragraph or subparagraph; i.e., the sections provide the instructions and guidance needed to complete the blanks.

5. After the blanks are completed, the Prime Item Development Specification is ready for final preparation (typing and review). It should be noted that those paragraphs and subparagraphs which have a "No" beside them in the worksheet should not be completely deleted from the prepared specification. Instead, these paragraphs and subparagraphs should be included in the prepared Prime Item Development Specification - however, under each paragraph and subparagraph that is not appropriate, the following phrase should appear: "Not Applicable." The "Not Applicable" phrase is used for several reasons:

a. In reviewing the prepared Prime Item Development Specification, it would not be possible to know if a paragraph or subparagraph was deleted unintentionally (accidently forgotten) or if it was purposefully deleted. Entering the words "Not Applicable" indicates that the paragraph or subparagraph was examined by the preparer and judged not appropriate for the current application.

b. If the paragraph or subparagraph was deleted, then the remaining subparagraphs (those identified as being necessary to include in the Prime Item Development Specification) would have to be renumbered. The renumbering would cause undue confusion; e.g., it would be difficult to trace the paragraphs and subparagraphs to this Handbook. In addition, the deletions might violate the requirements established by MIL-STD-490.

Format

The paragraph and subparagraph headings and their identification numbers in the Prime Item Development Specification correspond to those recommended in MIL-STD-490. The paragraphs and subparagraphs of the remainder of this Handbook have the same headings and identification numbers as those in the Prime Item Development Specification; i.e., each paragraph and subparagraph in the Prime Item Development Specification has a corresponding paragraph or subparagraph in this Handbook (with the same title and numerical identification).

The wording (stem) in each paragraph and subparagraph of the Prime Item Development Specification is repeated in the corresponding paragraph and subparagraph of this Handbook. This is to avoid having the preparer flip from the Handbook to the Prime Development Specification and vice versa.

Each corresponding paragraph and subparagraph in this Handbook has the same general format:

1. First appears the numerical identification and the paragraph or subparagraph heading (title).

2. Following this is the stem or wording that appears in the Prime Item Development Specification. The stem is contained in quotes to indicate that it is the same wording that appears in the Prime Item Development Specification.

3. Following the stem are four general sections for each paragraph and subparagraph:

a. Rationale and Guidance: This section discusses the reason the paragraph or subparagraph is included in the generic Prime Item Development Specification. It also provides guidance concerning the appropriateness of tha paragraph or subparagraph in specific situations; i.e., specific applications. In some cases this section also discusses the factors to be considered when completing the blanks. It discusses the requirements being requested.

b. Performance Parameters: This section presents suggested wording to be inserted in the blanks. Typically, the wording suggested originates from past maintenance trainer specifications, Military Standards and regulations, and the ISD-Based Training Equipment Design.

c. Background and Sources: This section, typically, provides the references for the suggested wording appearing in the Performance Parameters section. Often additional sources the preparer should consult are listed. Often the source of the requirement itself is given; i.e., the source that mandates the requirement appears in the specification that is given.

d. Lessons Learned: This section discusses any of the lessons that have been learned from previous maintenance trainer acquisition projects. Frequently discussed are the results that have been obtained by stating the particular requirement in certain ways. Often cautions are given not only in the way the requirement should be stated, but in the factors that the requirements must consider. The Lessons Learned section is intended to be informative and accumulative. It is the Lessons Learned section of this Handbook that makes this document a living document. Users of this Handbook are encouraged to add to the Lessons Learned section as experience is gained. The Lessons Learned section and the update of that section allow the users to take advantage of corporate history; i.e., to profit from the experience of others.

If the preparer finds it necessary to update either the specification or this Handbook (e.g., the Lessons Learned section), they should contact:

ASD/ENETS
Wright-Patterson Air Force Base
Dayton, Ohio 45433
(513) 255-4053 (commercial number)
785-4053 (AUTOVON number)

When making suggestions to improve the document, the document name and title should be given. Specific changes should reference the existing page number and paragraph or subparagraph identifier.

For convenience in updating the content in this Handbook each major paragraph heading (two-digit identification number) is started on a new page. This will facilitate adding addendums or suggestions made by the users.

For ease of use, the user is encouraged to do the following:

1. Tabs or dividers should be inserted at the beginning of each major paragraph heading. This will facilitate locating specific paragraph headings.

2. The Handbook should be bound in a three-ring binder to facilitate updating and to facilitate use; i.e., since the document is large, it is perhaps inconvenient to carry all of it - if the document is placed in a three-ring binder, those sections that are being worked on can be removed and later easily reinserted. The three-ring binder also permits updates or addendums to be added easily.

Warnings

The preparer of the Prime Item Development Specification (and user of this Handbook) may find it difficult to resist the temptation to use directly the suggested wording offered in the Performance Parameters section for each paragraph and subparagraph. In addition, they may find it difficult not to reference the Military Standards and regulations offered in this Handbook as sources.

This Handbook was designed to make the preparation of the Prime Item Development Specification an easier process. However, the preparer should not blindly use the suggested wording or automatically reference or use the referenced Military Standards and regulations. The Prime Item Development Specification (and this Handbook) are generic in nature and it is impossible, in a generic document, to allow for every situation and possible circumstance. The suggested wording and references should be used only if they are appropriate to the situation at hand. The preparer is encouraged to modify the suggested wording to reflect his or her current situation. In addition, he or she is encouraged to select carefully the Military Standards and regulations to be referenced in the prepared Prime Item Development Specification.

1.0 SCOPE.

1.1 GENERAL.

"This specification establishes the design, performance, and test requirements for a maintenance trainer which shall represent ______________________________."

Rationale and Guidance: It is necessary to specify the system(s), subsystem(s), or major component (such as a test station) to be simulated by the trainer as early as possible within the Prime Item Development Specification. This paragraph should be contained in all specifications regardless of the specific application. For convenience and guidance, the following definitions are offered: A system is defined as an assemblage comprised of interrelated and interacting subsystems designed to attain a predetermined purpose; e.g., the flight control system of an aircraft. A subsystem is defined as part of a system that has a purpose and function of its own and is designed to interact with its peer subsystems in order to attain the purpose or mission of the system. A major component is defined as the major device being simulated.

Performance Parameters: The blanks to be completed by the preparer communicate to the contractor or vendor the system(s), subsystem(s), or major component to be represented by the trainer; i.e., this information is provided only to give guidance to the contractor or vendor and to assure that the appropriate system, subsystem, or major component is simulated.

In the blank enter the system or subsystem to be simulated as well as the name of the weapon system where that system or subsystem is found; e.g., "flight control system of the F-16 aircraft."

Background and Sources: This information will typically be provided by the ISD team (see subparagraph 1.2a of the ISD-Based Training Equipment Design Specification).

Lessons Learned: In the past, maintenance trainers have usually been designed to represent systems rather than subsystems of the weapon system of interest. This subparagraph allows the possibility of subsystems. It also allows for the possibility of something other than a system or subsystem to be simulated, such as a test station.

1.2 APPLICATION.

"The requirements and verifications contained in this specification apply to maintenance trainers developed for the Air Force."

Rationale and Guidance: No input is required from the preparer.

Performance Parameters: None.

Background and Sources: None.

Lessons Learned: This specification may be applicable to maintenance trainers developed for other branches of the Military.

1.3 DEVIATION.

> "Any proposed design for a given application which will result in improvements in trainer performance, reduced life cycle cost, or reduced developmental cost through deviation from this specification or where requirements of this specification result in compromise in operational capability, the details shall be brought to the attention of the procuring activity for consideration of change."

Rationale and Guidance: No input is required from the preparer. This paragraph should appear in most applications of the generic Prime Item Development Specification. The paragraph was designed to allow the contractor or vendor freedom in suggesting alternative approaches and designs which meet or exceed the specified requirements. However, the paragraph stipulates that such suggestions (changes) must be brought to the attention of the procuring activity for consideration.

Performance Parameters: None.

Background and Sources: None.

Lessons Learned:

2.0 APPLICABLE DOCUMENTS.

2.1 ISSUE OF DOCUMENTS.

"a. The following documents of the issue in effect on ______ ______________________________________ are applicable to the extent specified herein. In the event of a conflict between the documents referenced herein and the content of this specification, the contents of this specification shall be considered as superseding requirements. Documents cited within the documents referenced herein shall not be applicable to this specification because of such reference."

"b. Following is a list of references and documents:

____

____."

This paragraph is divided into two sections or subparagraphs, a and b. Each is discussed separately below.

Rationale and Guidance (Item a): This item requests a date either by event or by a specific date. The date specified (i.e., entered in the blank) will become the effective date of the documents to be referenced in item b of this subparagraph. In addition to requesting the date, this subparagraph stipulates two conditions. First, it states that the requirements specified in the specification are to supersede any requirements made by reference to other documents (in case of a conflict between this specification and any referenced documents). To avoid conflicts you should read any documents which are referenced (i.e., do not blindly reference documents). The referenced documents should be read and the requirements stated in those documents should be matched against the requirements established in the specification. The second condition concerns references within references. Note that the wording assures the contractor or vendor that documents referenced (or cited) within the document referenced (and listed in item b) are not applicable to the specification. It if is desired to have the contractor or vendor follow the documents referenced within the documents listed in item b, you must list those additional reference under item b; i.e., the contractor is obligated to use only the documents listed in item b.

Item a of this subparagraph should appear in all applications of the generic Prime Item Development Specification.

Performance Parameters (Item a): Enter either a specific date (e.g., January 14, 1985) or an event date (e.g., on the initiation of bids or request for proposals).

Background and Sources (Item a): The APPLICABLE DOCUMENTS paragraph is mandated by MIL-STD-490 (page 33).

Lessons Learned (Item a): When conflicts occur, the contractor or vendor must be given guidance on what to do. This subparagraph is intended to provide that guidance. Note that the phrasing in the subparagraph assures contractors or vendors that only those documents listed in item b are applicable.

Some people are concerned about the phrasing, "... applicable to the extent specified herein ..." This Handbook adopts the philosophy that all pertinent documents should be clearly listed for the contractor or vendor. In addition, it is suggested that reference to these documents be as specific as possible. Thus, the phrasing "to the extent specified herein" is reasonable provided the preparer is careful in listing the appropriate documents; i.e., careful to list all applicable documents by paragraph and page number.

"b. Following is a list of references and documents: ______________________________."

Rationale and Guidance (Item b): This subparagraph provides an opportunity to list all documents used in the preparation of the Prime Item Development Specification; e.g., Military Specifications, Military Standards, Technical Orders, and other publications. Do not blindly include references and documents which are found in other training device specifications; each specification is unique to a particular application and the documents used in its preparation may not be appropriate your current application. Be sure to read all documents to be referenced before referencing them. Do not a give reference to an entire specification or standard unless you are positive the entire specification or standard is appropriate in this particular application.

It is suggested that the preparer develop the list of references or documents as the specification is being prepared. The preparer should not try to list the documents to be referenced from memory or by duplicating the documents referenced in a recent maintenance trainer specification. To be assured that all documents to be referenced are listed, this blank should be completed as the specification is being prepared; i.e., as a document is referenced (as in an "In accordance with ..." statement) in the completion of other paragraphs and subparagraphs, the preparer should get in the habit of automatically inserting that referenced document in this subparagraph.

Item b of this subparagraph should be in all applications of the generic specification.

Performance Parameters (Item b): The parameters to be entered are not necessarily performance parameters, although the referenced documents may specify particular performance requirements. When referencing a document or specification, identify the specific paragraph or subparagraph numbers from the documents that are applicable to this application. Also indicate the paragraph or subparagraph numbers in this application which use the referenced documents. For convenience consider presenting the list of documents in table form; e.g.,

REFERENCE TITLE	SPECIFIC PARAGRAPH AND/OR PAGE NUMBER OF REFERENCE	PARAGRAPH WITHIN THIS SPECIFICATION USING THE REFERENCE

For convenience, Appendix B of this document lists the references used to prepare this Handbook. However, you should not blindly list these references in this subparagraph.

If appropriate, list the references and documents supplied in the ISD-Based Training Equipment Design Specification. Also list the ISD-Based Training Equipment Design Specification itself if it is extensively used in the preparation of the current specification.

Background and Sources (Item b): See paragraph 1.5 of the ISD-Based Training Equipment Design Specification for a list of documents that were used in its preparation. Also see Appendix B of this document.

Lessons Learned (Item b): Often it is better to write out a small paragraph or subparagrarph than to reference it; e.g., instead of saying in accordance with paragraph XYZ of MIL-STD-XXX, it might be better to include the paragraph itself in this specification. This minimizes the time the vendor must spend in locating specific references and clarifies the specific intent of the preparer. Blanket referencing can often result in conflicting requirements. Thus, it is necessary that the preparer use only those references that are appropriate and consistent with other requirements specified in the Prime Item Development Specification.

2.2 AVAILABILITY OF DOCUMENTS.

"The specifications, standards, and publications listed in subparagraph 2.1b are available as indicated below:

____
____."

<u>Rationale and Guidance</u>: This subparagraph is included in the specification to inform the contractor or vendor how to obtain the documents (specifications, standards, and publications) listed in subpargraph 2.1b of the Prime Item Development Specification.

<u>Performance Parameters</u>: The following suggestions are offered for completing the blank:

"Unclassified Federal, Military, and other publications (excluding commercial) and standards are available from:

____
____."

The preparer should insert the name, address, and phone number where the documents can be obtained by the contractor or vendor. If a form must be completed by the contractor or vendor to request the documents, then the following should be added:

"____________ shall be completed to indicate the specification title, number, date, and any applicable amendments thereto by number and date. An initial request, where a prospective contractor or vendor does not have ____________________, may be submitted in letter form given the same specification as listed above, as well as the specific contract number."

The preparer should insert in the blanks provided above, the specific form number and/or title (e.g., DD Form 1425).

If a commercial publication is listed (e.g., ANSI Standards), then the following can be added:

"ANSI Standards may be ordered from:

American National Standards Institute
Attn: Sales Department
1430 Broadway
New York, NY 10018
Phone: (212) 354-3300."

Background and Sources: This is not a requirement, but may prove helpful to contractors and vendors.

Lessons Learned: The utility of providing this information in the Prime Item Development Specification is currently unknown.

3.0 REQUIREMENTS.

3.1 TRAINER DESCRIPTION.

"a. The target population(s) to be trained using the maintenance trainer is(are): ____________________ ____."

"b. The maintenance trainer shall be used for ____________ ____ training."

"c. After successful completion of the training program, graduates shall have a specialty code of ____________ ________ and shall be capable of performing ______ -level maintenance."

"d. The purpose of the maintenance trainer is to provide training which is directly transferable to the system(s)/subsystem(s) in the following task areas: ____.

The specific learning objectives to be achieved by the target population are further specified in subparagraphs 3.2.1.1, 3.2.1.2, and 3.2.1.3 of this specification.

"e. The maintenance trainer shall be used in the following way: ____________________________________ ____."

"f. The maintenance trainer shall have the following components: ______________________________________ ____.

The components are further specified in subparagraph 3.1.3 herein."

This subparagraph contains six (6) items to be completed, items a through f. Each item is discussed separately. However, it should be pointed out that the intent of this whole subparagraph is to provide background information and guidance to the contractor or vendor. Care must be taken in completing this subparagraph to assure that the trainer is adequately described. Provide as much detail as possible, so that the contractor or vendor knows how the trainer is to look and function (in general terms). The trainer will be described in detail throughout the remainder of the specification. This paragraph is designed to be

an advanced organizer for the contractor or vendor. Although the six items ara treated separately, the preparer may find it convenient to construct one paragraph which contains the same information.

"a. The target population(s) to be trained using the maintenance trainer is(are) ______________________________ ____."

<u>Rationale and Guidance</u> (Item <u>a</u>): This item is included in the specification to inform the contractor or vendor of the type of students who will be trained using the maintenance trainer. The type of students who will be using the maintenance trainer influences the design of the trainer; e.g., if students are already familiar with certain elements, the level of fidelity for those components possibly can be reduced.

<u>Performance Parameters</u> (Item <u>a</u>): In the blanks enter the predominate AFSC of the target population; if more than one predominate AFSC, enter more than one.

If it is necessary to describe the characteristics of the target population as well as supplying the predominate AFSC, then reference subparagraphs 2.3, 2.3.1, 2.3.2, and 2.3.3 of the ISD-Based Training Equipment Design Specification which contain a list of target population characteristics.

<u>Background and Sources</u> (Item <u>a</u>): This subparagraph is the same as subparagraph 2.2a of the ISD-Based Training Equipment Design Specification. Thus this information is to be supplied by the ISD analysts.

<u>Lessons Learned</u> (Item <u>a</u>):

"b. The maintenance trainer shall be used for ______________ ____ training."

<u>Rationale and Guidance</u> (Item <u>b</u>): This item is included to provide guidance to the contractor or vendor. It is not intended as a requirement. It will be useful for the contractor or vendor to know the type of training situation in which the maintenance trainer will be used.

<u>Performance Parameters</u> (Item <u>b</u>): Enter the desired type of maintenance training: field-level, resident, or depot training.

If desired, the preparer may find it useful to combine the information required by this item with the information required in item d.

Background and Sources (Item b): This subparagraph item is the same as subparagraph 2.2c of the ISD-Based Training Equipment Design Specification; i.e., this information will typically be supplied by the ISD analysts.

Lessons Learned (Item b): None. This is a new requirement and the utility of this information to the contractor or vendor is unknown.

> "c. After successful completion of the training program, graduates shall have a specialty code of __________ and shall be capable of performing ______________-level maintenance."

Rationale and Guidance (Item c): The information supplied in this item is only to provide the contractor or vendor with guidance and intent. It is not a requirement. The contractor or vendor should know the specialty code and level of maintenance that the graduate will be expected to achieve and perform at the end of training. This information will assist the contractor or vendor in designing the maintenance trainer. If the graduate will not change specialty codes or levels, the preparer may wish to specify that the training will be either follow-on or advanced and that graduates of the program will not be assigned a new or different specialty code.

Performance Parameters (Item c): In the first blank specify the Air Force Specialty Code (AFSC) that graduates will achieve after successfully completing the training program in which the maintenance trainer will be used. In the second blank enter the level of maintenance the graduate will be expected to perform after graduation; e.g., Intermediate, Organizational, or Depot.

Background and Sources (Item c): This item is the same as subparagraph 2.2b of the ISD-Based Training Equipment Design Specification; i.e., this information will be supplied to you by the ISD analysts.

Lessons Learned (Item c): This item has been included in previous training equipment specifications.

"d. The purpose of the maintenance trainer is to provide training which is directly transferable to the system(s)/subsystem(s) in the following task areas: ______________________________ ______________________________."

The specific learning objectives to be achieved by the target population are further specified in subparagraphs 3.2.1.1, 3.2.1.2, and 3.2.1.3 of this specification.

Rational and Guidance (Item d): This item is intended to give the contractor or vendor a brief description of the task area to be acquired and/or practiced on the maintenance trainer being specified. This is only a brief description. The specific training objectives and specific tasks to be acquired using the proposed trainer are further specified in subparagraphs 3.2.1.1 and 3.2.1.2 of the Prime Item Development Specification.

Performance Parameters (Item d): This item is the same as subparagraph 1.2b of the ISD-Based Training Equipment Design Specification. Enter here what is entered in that subparagraph. If an ISD analysis was not completed for this specific application, then enter the general task areas the trainer is going to provide practice in; e.g., "Troubleshooting fuses." Do not list tasks; list only broad task areas.

Background and Sources (Item d): See subparagraph 1.2b of the ISD-Based Training Equipment Design Specification for the task areas to be trained using the proposed maintenance trainer.

Lessons Learned (Item d): This information has been specified in previous training equipment specifications.

"e. The maintenance trainer shall be used in the following way: ______________________________ ______________________________."

Rationale and Guidance (Item e): This item is included to provide the contractor or vendor information concerning how the maintenance trainer is going to be used (by the instructor) to attain the specific learning objectives and to provide the student an opportunity to practice and/or acquire the specified tasks.

Completion of this item usually requires a lengthy narrative. This narrative must contain:

- A description of the problem classes to be presented by the trainer.

- A description of trainer, instructor, and student actions.

Recall that the contractor or vendor must be able to read the narrative and fully understand how the trainer is going to be used. Therefore, you should specify what the instructor must do to select the problem or student exercise, what action the student must take, and how the trainer is to act given the student actions. You should include as much detail as possible.

It should be pointed out that the purpose of the trainer is different than its use. Its purpose is to train students to perform specific tasks. It may be used in different ways to achieve its purpose. What the contractor or vendor needs to know is how the instructors intend to use the trainer to achieve the specific learning objectives.

Performance Parameters (Item e): Enter the same information in this blank as in subparagraphs 3.2, 3.2.1.2a, 3.2.1.2b, 3.2.1.2c, and 3.2.1.2d of the ISD-Based Training Equipment Design Specification or reference these subparagraphs using an "in accordance with" statement; e.g., "The maintenance trainer shall be used in accordance with subparagraphs 3.2.1.2 of the ISD-Based Training Equipment Design" (providing the ISD-Based Training Equipment Design Specification is included as an appendix or attachment to the Prime Item Development Specification). If the ISD team has not prepared an ISD-Based Training Equipment Design Specification or if an ISD analysis has not been performed, then you must obtain from the instructors information concerning how they intend to use the proposed trainer.

Background and Sources (Item e): See subparagraphs 3.2 and 3.2.1.2 of the ISD-Based Training Equipment Design Specification which provide you with the specific information to be inserted in the blanks.

Lessons Learned (Item e): How the trainer is intended to be used influences its design and capabilities. Descriptions that have appeared in other specifications have often been too general to be helpful to the contractor or vendor. An attempt is being made here to make the descriptions more illustrative and informative. You should include as much detail as possible. The preparer should not feel apprehensive about possibly duplicating information here that is contained in other parts of the specification.

"f. The maintenance trainer shall have the following components: ______________________________
______________________________.

The components are further specified in subparagraph 3.1.3 herein."

Rationale and Guidance (Item *f*): This subparagraph should contain a list of the components of the trainer. When completing item *e* above, these components may be mentioned; if that is the case, this item need not be included in this particular application. It should be pointed out that the components specified in this item must be further described in subparagraph 3.1.3 of the Prime Item Development Specification so be sure all components are included in either this item or item *e* of this subparagraph.

It is not the intent of the Handbook to force a certain configuration on the trainer. However, most trainers typically have four major components.

- Instructor Station: This unit usually contains the controls necessary to set the mode of the trainer, monitor student performance, store and retrieve data, and control the learning environment (e.g., cue enhancement and problem selection controls).

- Student Station: This unit usually contains the controls, displays, and indicators that are going to be simulated. It also usually contains those devices and controls which allow the student to receive remedial instruction (e.g., computer-assisted instruction) and to make instructional responses which are not directly made on the simulated equipment.

- Instructional System Programs: These are software programs designed to control the learning environment presented by the trainer, for example, software allowing the instructor to create new student exercises, to create instructional text material, etc. This is considered a component of the trainer.

- Computational System: The computational system includes both the computational system hardware and the software required to operate the trainer and the computational hardware. It may be difficult to perceive software as a trainer component; however, software is treated as part of the computational system and requirements concerning the organization and purpose of the software must be specified.

In addition, maintenance trainers may also contain other components, such as 35mm slide projectors, screens, and slide containers, covers, etc. It is important to list all the components of the trainer in this section of the Prime Item Development Specification.

Performance Parameters (Item *f*): Enter the components comprising the maintenance trainer. Much of this information, if not all of

it, is contained in the ISD-Based Training Equipment Design Specification. The specific subparagraphs used from that specification are identified in the next paragraph.

NOTE: For this item list only the components; do not describe them. (The components listed in this item must be fully described in other subparagraphs of this specification.)

Background and Sources (Item f): If a student station is required, it will be indicated in subparagraph 5.3 of the ISD-Based Training Equipment Design Specification. Furthermore, if there is a student station, it will be described in subparagraphs 5.3.1 and 5.3.2 of the same document.

If an instructor station is required, it will be indicated in subparagraph 5.4 of the ISD-Based Training Equipment Design Specification. Furthermore, if there is an instructor station, it will be described in subparagraphs 5.4.1 and 5.4.2 of the same document.

The instructional system program components are described in subparagraphs 3.7.1 through 3.7.1.4 of this Handbook.

The computational system component is not described in the ISD-Based Training Equipment Design Specification. However, see subparagraph 3.1.3 and subparagraphs 3.7.2 through 3.7.2.3 and their accompanying subparagraphs of this Handbook for advice and guidance concerning the type of software/firmware that is usually contained on a maintenance trainer. The preparer should be aware, however, that the ISD-Based Training Equipment Design Specification may have implications for the software requirements. Thus, the preparer may find it necessary to review the ISD-Based Training Equipment Design Specification to complete the component blank.

For information on use of existing software, see AFHRL-TP-84-49 paragraph 2.1.2.4.

Lessons Learned (Item f): Inadequate description of the simulator/trainer often leads to the delivery of trainers which cannot be used as the instructors and ISD analysts intended. It is essential to construct this section of the Prime Item Development Specification carefully, so that what is being required is clearly communicated to the contractor or vendor. How the instructor intends to use the trainer must be carefully described so that the trainer is delivered in a configuration which is usable by the instructor for its intended purpose.

3.1.1 ITEM DIAGRAM(S).

"____
____."

Rationale and Guidance: MIL-STD-490 requires an item diagram to be placed in the training equipment specification. The item diagram or diagrams should be an item-level functional schematic(s) (see Background and Sources below for an example). These diagrams must illustrate the functional relationship between the major components listed in subparagraph 3.1f of the Prime Item Development Specification. That is, the diagrams should show the functional relationships between the computer software (and processor) - if it is listed as a component and the instructor station (if listed as a component). It should illustrate the relationship between the major components (instructor station, student station, and software) and such items as the slide projector (if one was indicated) and/or the remedial instruction devices (e.g., computer-assisted instruction devices).

Accompanying the item diagram(s) should be a brief description of the diagram(s), explaining, in narrative form, the specific functional relationships of importance.

Performance Parameters: Enter the item diagram(s) and a narrative describing or explaining the diagram(s). A good example of a diagram appears in Specification No. 16PS028A (March 1979); for convenience that diagram is included in this Handbook as Figure 1.

Unfortunately, Specification No. 16PS028A did not include a narrative description of the diagram.

Background and Sources: This subparagraph requirement originates from MIL-STD-490 (page 33), which reads:

> "... This paragraph shall incorporate, where applicable, either directly or by reference, the item level functional schematics. This paragraph will cover the top level functional flow diagrams of the configuration item and include diagrammatic presentations to the level required to identify all essential functions."

The narrative accompanying these diagrams is a new requirement.

Lessons Learned: The utility of the item diagram(s) has not been estimated. But it is intuitively obvious that such diagrams specify exactly the kind of functional relationship that the Air Force is requiring among the major components of the trainer. Item diagrams included in Prime Item Development Specifications have been viewed as a mixed blessing. If the design of the trainer is precisely known, item diagrams can be of use to the contractor or vendor. However, if the design of the trainer is not clear, the inclusion of an item diagram may give the contractor or vendor a false sense of how the trainer should function. It has been recommended that, to avoid the misuse of

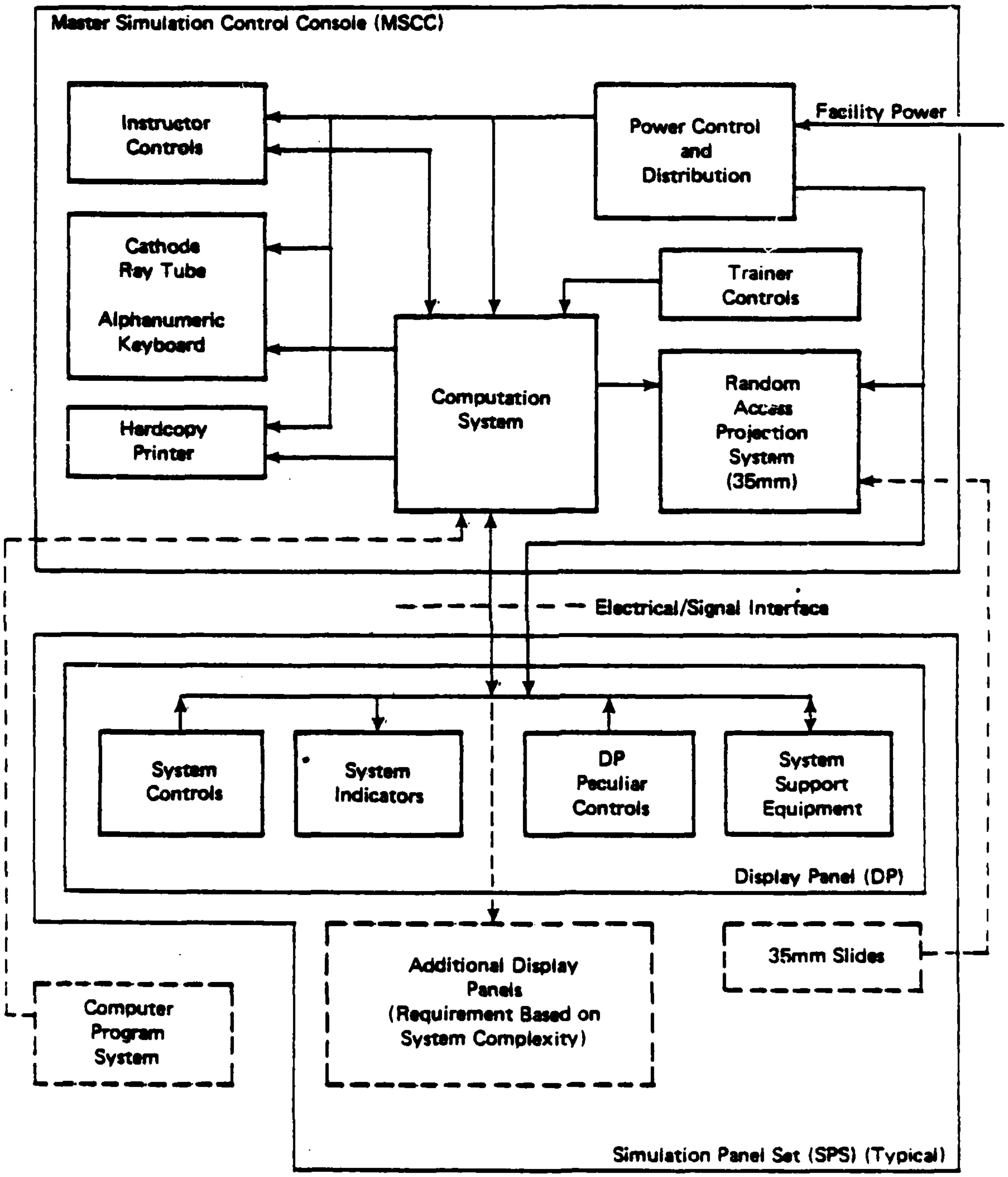
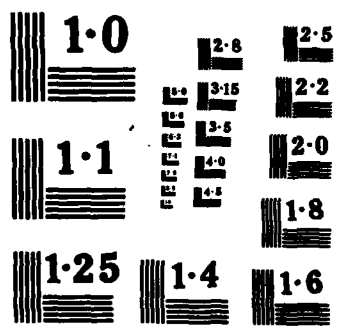


Figure 1. Example Item Diagram

AD-A154 108 MAINTENANCE TRAINING SIMULATORS PRIME ITEM DEVELOPMENT 2/5
SPECIFICATION MODE..(U) APPLIED SCIENCE ASSOCIATES INC
VALENCIA PA R J HRITZ ET AL. APR 85 AFHRL-TP-84-44
UNCLASSIFIED F33615-78-C-0019 F/G 5/9 NL


1·0
2·8
2·5
3·15
2·2
3·5
1·1
4·0
2·0
4·5
1·8
1·25
1·4
1·6

Rationale and Guidance: MIL-STD-490 requires an item diagram to be placed in the training equipment specification. The item diagram or diagrams should be an item-level functional schematic(s) (see Background and Sources below for an example). These diagrams must illustrate the functional relationship between the major components listed in subparagraph 3.1f of the Prime Item Development Specification. That is, the diagrams should show the functional relationships between the computer software (and processor) - if it is listed as a component and the instructor station (if listed as a component). It should illustrate the relationship between the major components (instructor station, student station, and software) and such items as the slide projector (if one was indicated) and/or the remedial instruction devices (e.g., computer-assisted instruction devices).

Accompanying the item diagram(s) should be a brief description of the diagram(s), explaining, in narrative form, the specific functional relationships of importance.

Performance Parameters: Enter the item diagram(s) and a narrative describing or explaining the diagram(s). A good example of a diagram appears in Specification No. 16PS028A (March 1979); for convenience that diagram is included in this Handbook as Figure 1.

Unfortunately, Specification No. 16PS028A did not include a narrative description of the diagram.

Background and Sources: This subparagraph requirement originates from MIL-STD-490 (page 33), which reads:

> "... This paragraph shall incorporate, where applicable, either directly or by reference, the item level functional schematics. This paragraph will cover the top level functional flow diagrams of the configuration item and include diagrammatic presentations to the level required to identify all essential functions."

The narrative accompanying these diagrams is a new requirement.

Lessons Learned: The utility of the item diagram(s) has not been estimated. But it is intuitively obvious that such diagrams specify exactly the kind of functional relationship that the Air Force is requiring among the major components of the trainer. Item diagrams included in Prime Item Development Specifications have been viewed as a mixed blessing. If the design of the trainer is precisely known, item diagrams can be of use to the contractor or vendor. However, if the design of the trainer is not clear, the inclusion of an item diagram may give the contractor or vendor a false sense of how the trainer should function. It has been recommended that, to avoid the misuse of

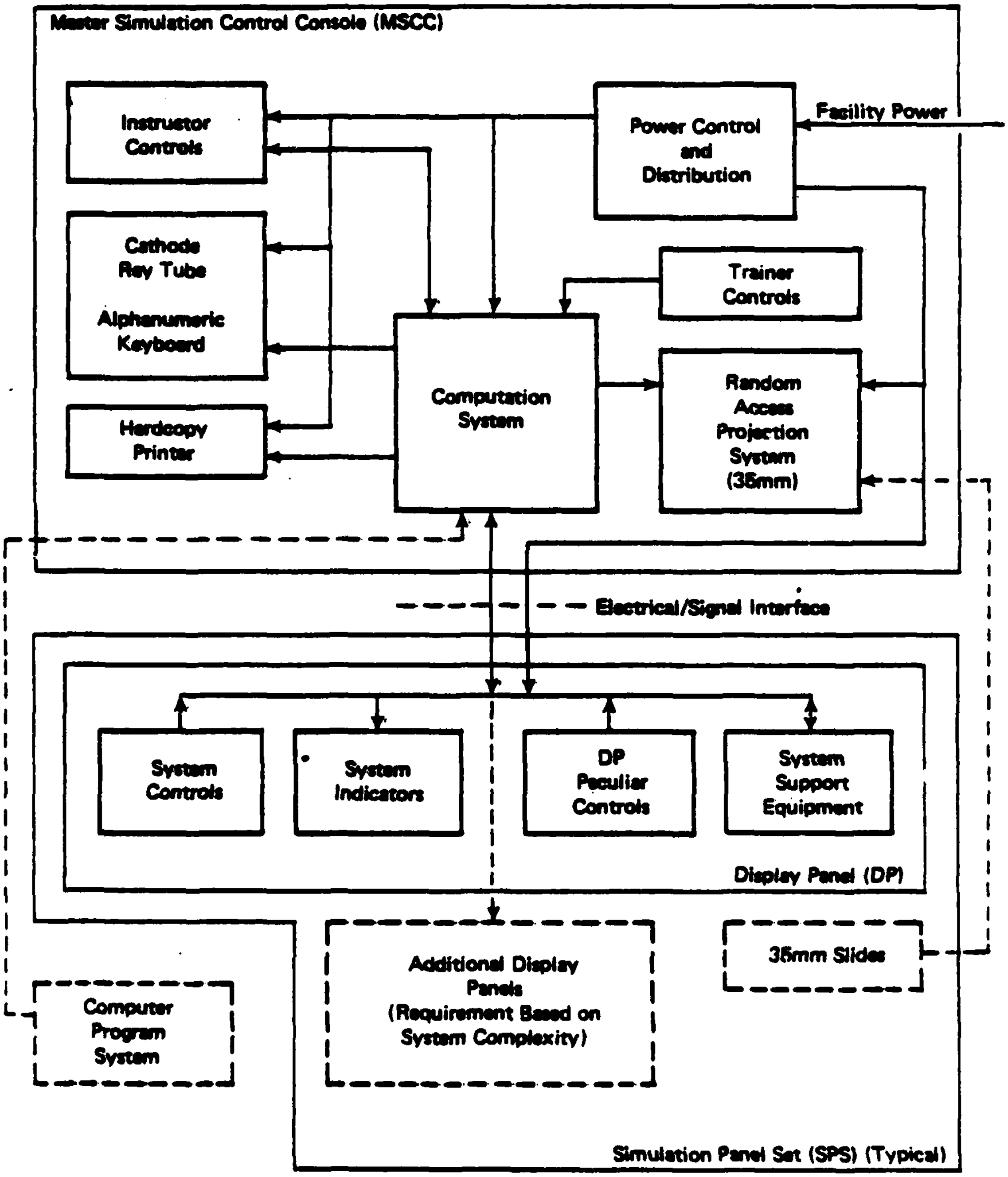


Figure 1. Example Item Diagram

the item diagram, it (the item diagram) be included in Section 6 of the specification (the Notes section). In this way, if the item diagram is only an estimate, then the contractor or vendor would feel free to adjust or modify the item diagram.

Furthermore, the utility of the accompanying narrative has not been estimated since it is a new requirement, but such a narrative should obviously make it clear what relationships between the components are essential.

3.1.2 INTERFACE DEFINITION(S).

"____

____."

Rationale and Guidance: Usually two types of interfaces are required on a typical maintenance trainer: Internal Interface (the interface between major components within the maintenance trainer) and External Interface (the interface between the trainer and other items such as off-the-shelf support test equipment).

It is suggested that each type or kind of interface be given its own subparagraph heading (e.g., 3.1.2.1 INTERNAL INTERFACE and 3.1.2.2 EXTERNAL INTERFACE).

Since it is desired to leave as much latitude as possible to the contractor or vendor, you need only specify any peculiar or necessary interface requirements or enter any interface you are aware of. In addition, since you may not know the exact design of the intended trainer, you may not be aware of all the interfaces that are required. Thus, the requirements you enter should not be unnecessarily restrictive and should allow the contractor or vendor some flexibility.

MIL-STD-490 (page 33) requires that "... the functional interfaces shall be specified in quantitative terms of input/output voltages, acceleration, temperature ranges, shock limitations, loads, speeds, pitch and roll rates, etc. ... Physical interface relationships shall be expressed in terms of dimensions and tolerances." Although MIL-STD-490 requires the use of quantitative terms, you may find the use or specification of voltages unnecessarily restrictive to the contractor or vendor. In addition MIL-STD-490 (page 33) further stipulates that, "This paragraph shall incorporate ... interface control drawings, and other engineering data as necessary to define all functional and physical interfaces required to make the item [maintenance trainer] compatible with other items and to make the major components compatible within the item." Thus, when describing the interfaces (both internal and external), it is essential to specify both physical and functional interfaces.

If possible, the functional interfaces (both internal and external) should be included in the diagram(s) offered in subparagraph 3.1.1 of the Prime Item Development Specification; i.e., any interface listed listed here should also appear in that item diagram.

Performance Parameters: Internal interfaces include the functional and physical relationship between the major components (instructor station, student station, computational system and instructional system programs and other items such as slide projector, CRT [cathode-ray tube], hardcopy printer, and any support equipment [e.g., test support equipment]). Where possible and where such statements are considered not restrictive, specify voltages between the major components. Also, if mechanical connections are needed between the components, be sure to specify them accurately (e.g., air hose connections, mechanical linkages, etc.). When specifying internal electrical connections, specify the type of cable required; also specify on what component the female connector will be located. When specifying mechanical connectors, give all necessary dimensions and tolerances, if known. Consider the following phrasing:

> "Each trainer panel shall be designed as an integral unit, requiring only electrical connections with the instructor station. Connection shall be achieved with a minimum of _____ (number) of connectors located at the rear base of the simulated panel on the _____________ (right/left) side. Each electrical connection shall be a minimum of ________ (meters). The instructor station connector shall be female and shall be rigidly mounted on the instructor station at _____________ (specify location). Various configurations should not put undue stress or strain on the connectors. The electrical connectors shall contain spares in accordance with subparagraph 3.3.1.4 herein.
>
> Those trainer panels which require multi-display panel configurations shall require panel-to-panel interface only. In such cases the contractor shall propose efficient means of accomplishing this interface and obtain approval/disapproval at the Preliminary Design Review (PDR)."

Note that the above suggested phrasing discusses only electrical interfaces; however, a similar type of paragraph can be developed for mechanical interfaces, if needed.

Be sure to specify the interface between the various components and the support equipment, if support equipment is to be used. It is also important to specify any interfaces between the computer and any support equipment.

External interfaces include the functional and physical relationships of the triner and the facility (e.g., power supply interfaces and mechanical interfaces between the trainer and the facility). All external interfaces included in the functional diagrams required by subparagraph 3.1.1 should be discussed in this subparagraph. External interfaces vary greatly between trainers so an example paragraph is not provided.

Background and Sources: This requirement is specified in MIL-STD-490 (page 33). Also see AFHRL-TP-84-49 paragraphs 2.2.2.4 and 2.2.2.11, for suggestions on computer/facility interface and hydraulic interface requirements.

Lessons Learned:

3.1.3 MAJOR COMPONENT LIST.

"The maintenance trainer shall be composed of the following major components: ____ ____."

Rationale and Guidance: In this subparagraph enter the major components of the maintenance trainer. It should be recalled that a major component list was provided in subparagraph 3.1f of the Prime Item Development Specification. The list requested in this subparagraph includes those plus all the subcomponents within each of the major components. The subcomponents should be listed in an indented relationship or fashion; e.g.,

a. Major component ________________, composed of:

(1) Subcomponent 1
(2) Subcomponent 2

. .
. .
. .

(N) Subcomponent N composed of:

(a) ________________
(b) ________________

. .
. .
. .

(n) ________________

b. Major component ________________, composed of:

This subparagraph should list only the major components and the subcomponents within those major components. It is not necess-

ary, within this subparagraph, to describe each of the components and subcomponents. The components and subcomponents listed within this subparagraph are described throughout this specification. The purpose of this subparagraph is only to provide the list of components and subcomponents that are to be discussed.

As an alternative to the indented organization suggested above, the preparer may find it convenient to have a subparagraph for each major component. For example, the typical maintenance trainer usually consists of four major components: the Instructor Station, the Student Station, Instructional System Programs (software controlling instructional features), and the Computational System (computer/processor, peripheral equipment, and software).

The preparer may find it more efficient and economical to have a subparagraph for each of the four major components; e.g., 3.1.3.1 INSTRUCTOR STATION COMPONENT LIST, 3.1.3.2 STUDENT STATION COMPONENT LIST, 3.1.3.3 INSTRUCTIONAL SYSTEM PROGRAMS COMPONENT LIST, and 3.1.3.4 COMPUTATIONAL SYSTEM COMPONENT LIST. The particular format to be used is left to the discretion of the preparer.

Although it has been suggested that maintenance trainers typically have four major components, it should be stated again that it is not the purpose or intent of this Handbook to force a particular maintenance trainer configuration. It is within the spirit of this last sentence that the list of possible components and subcomponents is offered in the Performance Parameters section of this subparagraph.

Performance Parameters: For each of the four typical major components of a maintenance trainer, a list of possible subcomponents is offered below. It should be stressed that the lists are only presented to provide guidance (the lists are not intended to be exhaustive or comprehensive); i.e., the lists may vary depending upon the particular application.

The following subcomponents and/or items may be located on or be part of the INSTRUCTOR STATION:

- Instructional Feature Controls:
  - On/Off Select Sensing.
  - On/Off Select Recording.
  - On/Off Select Reporting.
  - On/Off Select Monitoring.
  - On/Off Select Feedback.
  - On/Off Select Cue Enhancement.
  - Feedback Message Adjust.

- Adjustable Criteria Control.
- Rate Adjust Control.
- Signal-to-Noise Adjust.
- Malfunction Insertion Control.
- System Parameter Control.
- On/Off Select Next Activity.
- On/Off Select Freeze.

These instructional features are defined in subparagraph 1.4 of the ISD-Based Training Equipment Design Specification. For convenience, these definitions are also provided in Appendix A of this document.

- Slave or Repeater Displays and Controls (displays located on the Instructor Station which are also located on the Student Station). Such displays and controls are used by the instructor to observe student performance or to override or adjust parameter settings.

- Projection System (e.g., to view slides). The projection system can be further divided into the following subcomponents:

  - Projector (specify if random access).
  - Screen (specify if rear view).
  - Slide Container.
  - Slides.
  - Laser video disk (manual and computer-controlled).

It is not the purpose of this Handbook to list all the possible components or all possible types of projection systems. For example, the type and nature of the projection system will depend on the specific application. The preparer should not forget the feasibility of using video cassettes or video disks instead of slides. Video technology can allow video disks to be controlled either manually or by computer or processor.

When specifying the components that are on the trainer, consideration should be given to listing components or subcomponents that are already in the DOD inventory. This will make the logistics problems easier to handle when the trainer is actually delivered. However, an effort should be made to guarantee that the item in the DOD inventory is an item that will work on the trainer; i.e., will meet the functional requirements specified herein. A component should not be specified only because it is in the DOD inventory; rather, it should be selected because it will be acceptable on the trainer. In specifying components, the preparer should consider not only the logistics

problems, but also the initial cost and life cycle cost of the components. Also, in selecting and specifying components, consideration should be given to the state-of-the-art of the current technology; e.g., a computer processor in DOD inventory may be outdated by current technology standards.

To determine the controls and displays on the Instructor Station for this specific application, see subparagraphs 5.0, 5.1, 5.2, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.4, 5.4.1, and 5.4.2 of the ISD-Based Training Equipment Design Specification.

Often some of the subcomponents of the computational system are also located on the Instructor Station, such as:

- Alphanumeric Keyboard (remote): Used by the instructor to initialize the system, set parameter values, give instructions to the trainer, etc.

- Cathode-Ray Tube (CRT) or alternate display system: Used by the instructor to monitor student performance, monitor the status of the system, etc.

- Hardcopy Printer: Used by the instructor to obtain hard copies of those items on the CRT, to print a record of student performance, etc.

- Computer Main Frame or Micro Processor.

- Storage Device (e.g., magnetic tape, hard disk, floppy disk, etc.).

These items can be listed either under INSTRUCTOR STATION or COMPUTATIONAL SYSTEM or both. If they are listed under COMPUTATIONAL SYSTEM, they should be identified as being located on the Instructor Station, unless the preparer is willing to allow the contractor or vendor to determine their location.

The following subcomponents or items may be located on or be part of the STUDENT STATION:

- All displays, controls and indicators that are to be simulated (see subparagraphs 4.2.2, 4.2.3, and 4.4 of the ISD-Based Training Equipment Design Specification).

- Cathode-Ray Tube (CRT) or alternate display system.

- Alphanumeric Keyboard.

- Instructional Feature Controls (see list above for controls on the Instructor Station - any of these controls

can be on the Student Station if it is desired to have the student, as well as the instructor, control certain aspects of the learning environment).

Note that the CRT and the Alphanumeric Keyboard should also be listed under COMPUTATIONAL SYSTEM, with a note that they are to be located on the Student Station.

The INSTRUCTIONAL SYSTEM PROGRAMS component is composed of software designed to control instructional features (e.g., to allow the instructor, before each exercise, to change the status of system or subsystem parameters, to change the parameters controlling the student monitoring activities, to create "new" student exercises, etc.). To determine which programs in this category are needed (i.e., to be listed here), the preparer should review subparagraphs 5.0, 5.1, 5.2, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, and 5.2.9 of the ISD-Based Training Equipment Design Specification. The ISD-Based Training Equipment Design Specification discusses how the instructional features are selected. For convenience, the type of programs which belong to this category are listed below:

- Student Performance Monitoring Program(s). These are programs to sense, report, score, and record key parameters and values associated with student responses, such as student actions and their associated values (e.g., display readings) of the simulated system at the time of the student response[s]).

- Stimulus Control Program(s). These are programs which control the rate of stimulus presentation, the signal-to-noise ratio, and the amount of cueing and aiding. Such programs are needed only if stimulus instructional features are indicated by the ISD analysis.

- Feedback Control Program(s). These are programs which control the feedback rate and schedule (e.g., provide immediate feedback or delayed feedback) and the content of the feedback message. Such programs are needed only if feedback instructional features are indicated by the ISD analysis.

- Next Activity Control Program(s). These are programs which control the selection of the next activity (either after a freeze or during remedial computer-assisted instruction). Such programs are needed only if next activity intructional features are indicated by the ISD analysis.

- Freeze Control Program(s). These are programs which cause the simulator to freeze after a procedural error, critical error, or a fatal error (an error causing personnel injury or damage to the equipment). This program also allows the instructor to specify when the freeze is to occur.

- Sign-In Program(s). These are programs which allow students to sign-in and automatically create a file or record for their responses.

- Malfunction Creation Program(s). These are programs which allow the instructor to create new malfunction conditions.

- Student Exercise Creation Program(s). These are programs which allow the instructor to create new lesson exercises either for the student or for demonstration purposes.

Before preparing the content for this subparagraph, the preparer is encouraged to read paragraph 3.7 and its associated subparagraphs of this Handbook.

The subcomponents or items listed below may be part of the COMPUTATIONAL SYSTEM depending upon the specific application. The listed items can parallel the subparagraphs under 3.7.2 or may be organized in any other way that seems reasonable. The computational system is defined as:

> "The digital computational system shall consist of a commercially available general purpose digital computer configuration with the options and peripheral equipment specified herein, and associated software (computation programs) to activate and support the simulator."

Notice that the definition suggests that the computational system has three major components - the computer or processor itself, the peripheral equipment (e.g., keyboards, storage devices, printer, etc.) and the associated software (computer programs, other than instructional system programs). Also included within this major component should be listed any interface equipment (computer interface equipment). The following list of possible interface equipment is suggested:

> "The interface system shall include analog-to-digital input conversion equipment, digital-to-analog output conversion equipment, discrete inputs, discrete outputs, digital-to-synchro outputs, etc."

A list of peripheral and auxilliary equipment follows:

- Digital Remote-control Unit (DRU). This is used to control, monitor, freeze, change register and memory contents, display contents, and to halt and restart the operation.

- Magnetic Disk System (this includes the driver and controllers).

- Remote CRT Terminal Display/Keyboard. The terminal shall include a hardcopy device; i.e., be a printer. The terminal should interface with the magnetic disk system and the CRT display.

- Magnetic Tape System. The magnetic tape system shall provide an on-line, real-time backup to the disk system.

- Support Peripherals. The following support peripherals (including controllers and devices) are suggested:

    - Card Reader.
    - Card Punch.
    - Line Printer.
    - Keypunch.
    - Additional Magnetic Disk Unit.
    - Program Restrict/Instruction Trap.
    - Address Trap.
    - Hardware Bootstrap for the Card Reader.

Most of the peripheral equipment listed above will probably not be needed in a maintenance trainer (e.g., card reader, card punch, and keypunch). However, they are listed above because they are specified in military documents, and inclusion here may provide additional ideas to the preparer.

Another device which should be listed under the COMPUTATIONAL SYSTEM is a real-time clock. A real-time clock(s) shall be provided for timing and operation of the complete computational system.

A list of software programs is presented below:

- Real-Time Operational Program(s) (Programs to perform real-time computation and input/output to implement all simulated systems). These programs usually include:

  - Supervisor Program(s). Programs designed to maintain control over the functional system-oriented and input/output-oriented real-time programs. These control the update of the data bases.

  - Simulation Program(s). Programs designed to accurately simulate the dynamics of all systems and subsystems. These include those programs that generate system parameters or values which control displays, simulate the reaction of manipulated controls, or allow the student or instructor to input or output system parameters.

  - Input/Output Program(s). These programs are for both real-time and non-real-time mapping and control of inputs/outputs with the functional simulation programs.

  - Real-Time Alphanumeric/Graphic CRT Display Program(s). These are operational programs to implement the information processing, storage, and retrieval of all displays and dynamically changing information.

  - Library Program(s). These are operational programs designed to provide real-time storage and retrieval of all on-line computer programs.

- Simulator Support Program(s). These are programs developed to support the operational training and use of the maintenance trainer.

  - Simulation Verification Program(s). These are programs to verify the Simulation Program(s), to assure that

they reflect an accurate representation of the mathematical model being simulated. Such programs should be specified only if the system or subsystem being simulated is complex. Often maintenance trainers need not have complicated mathematical models.

- Other Verification Program(s). These are programs to verify the operational cycle time and spare time remaining within the cycle and frame period.

- Trainer Readiness Check Program(s). These are programs which output a sequence of check parameters on the simulator and stop when a non-standard value is obtained. These programs are not intended as calibration programs, but rather as a quick systems operational check.

- Modification Support Program(s). These are programs to update the simulation program and any data bases used by any of the application programs, and to update or modify any of the instructional features programs. This would include those involved in performance data reductions or tabularizations. Modification programs are extremely important; it is through these programs that the simulated system can be kept current.

. Computer Program System Support Program(s). These would be standard support programs; e.g.,

  - Resident Operating System (Program).

  - Peripheral Operating/Handler System (Programs). These are the programs used to control and handle the peripheral devices, such as the printer, the storage devices, etc.

  - Loaders.

  - Assemblers.

  - Compilers.

  - Memory Dump Programs. These are programs which allow the user to dump or output any number of specified memory locations or special registers.

  - Mathematical Library. (Standard mathematical functions; e.g., division, multiplication, square root, etc.)

  - Copy Routines.

- Trace Routines. Used during debugging.

- Maintenance and Test Program(s). These are programs designed to fully test the operation of the computational system and the interface equipment. When malfunctions occur in the computer(s) or the trainer, these programs should provide sufficient information to identify and locate the malfunction:

  - Computer Diagnostic Program(s). Used to isolate malfunctions in the digital computer - it is usually desired to have these fully automatic.

  - Real-Time Interface Equipment Diagnostic Program(s). Used to check the functioning of the interface equipment.

  - Discrete Input and Output Test Program(s). Used to check the functioning of the input/output channels.

  - Analog Input and Output Test Program(s). Used to exercise all of the analog and synchro-devices through their full range of operation.

  - Program Control Test of Real-Time Clock. Used to check the clock for accuracy and proper functioning.

  - Other Diagnostic Program(s). Used to check the proper functioning of input/output controllers (external to the computer), special peripheral equipment, special purpose displays, etc.

- Calibration Test Program(s). Used to check the accuracy and flow of signals, both statically and dynamically, through the full range of variables between the computer and all signal sources and terminal points.

The brief discussion above suggests the following list of subcomponents for the COMPUTATIONAL SYSTEM:

- Computer Main Frame or Processor.

  - Real-Time Clock.

- Interface Equipment.

  - Analog-to-Digital Input Conversion Equipment.
  - Digital-to-Analog Output Conversion Equipment.
  - Discrete Inputs.
  - Discrete Outputs.
  - Digital Inputs.
  - Digital Outputs.
  - Digital-to-Synchro Outputs.

- Peripheral and Auxilliary Equipment.

  - Digital Remote-control Unit (DRU).
  - Magnetic Disk System.
  - Remote CRT Terminal Display/Keyboard.
  - Magnetic Tape System.
  - Other Peripheral Devices.

    - Card Reader.
    - Card Punch.
    - Line Printer.
    - Keypunch.
    - Additional Magnetic Disk Unit.

- Software (computer programs).

  - Real-Time Operational Program(s).

    - Supervisor Program(s).
    - Simulation Program(s).
    - Input/Output Program(s).
    - Real-Time Alphanumeric/Graphic CRT Display Program(s).
    - Library Program(s).

  - Simulator Support Program(s).

    - Simulation Verification Program(s).
    - Other Verification Program(s).
    - Trainer Readiness Check Program(s).
    - Modification Support Program(s).

  - Computer Program System Support Program(s).

    - Resident Operating System.
    - Loaders.
    - Assemblers.
    - Compilers.
    - Memory Dump Programs
    - Mathematical Library
    - Copy Routine.
    - Trace Routine.

  - Maintenance and Test Program(s).

    - Computer Diagnostic Program(s).
    - Real-Time Interface Equipment Diagnostic Program(s).
    - Discrete Input and Output Test Program(s).

- Analog Input and Output Test Program(s).
- Program Control Test of Real-Time Clock.
- Other Diagnostic Program(s) (e.g., list of special peripheral equipment).

- Calibration Test Program(s).

Additional Information. In addition to listing the major components and subcomponents, the following items should appear in this subparagraph of the Prime Item Development Specification:

"There shall be______(number) Instructor Station(s). There shall be______(number) kinds of Instructor Stations."

"There shall be______(number) Student Station(s). There shall be______(number) kinds of Student Stations."

"There shall be______(number) Computational System(s)."

The information to be supplied in the first two blanks can be obtained from reading the following subparagraphs of the ISD-Based Training Equipment Design Specification: 5.3.1a, 5.3.1b; 5.4.1a, and 5.4.1b. The information requested in the third blank must be supplied by the preparer in consultation with a computational system expert. If it is not known if multiple processors will be needed, the preparer can delete the last (third) statement or make a statement indicating that the contractor or vendor shall determine the need for multiprocessors.

If the instructor stations and student stations do not appear in the current application, then the following sentence should appear in this subparagraph.

"There shall be______(number) station(s) and _____ (number) kinds of station(s)."

This information is required so that the contractor or vendor knows exactly how many stations of each kind are needed. To determine the number of stations needed, consider the following factors:

- Anticipated number of students to be trained.

- The number of students that can be trained using one trainer.

There is a current trend to have only one station which serves as both the Instructor Station and the Student Station. If only one unit is going to be required, then the subcomponents suggested for each station in the Performance Parameters section of this subparagraph can be combined to form one major component category.

To avoid possible confusion by the contractor or vendor, it has been suggested that this subparagraph also specify the expected class size. The expected class size can influence the number of components (e.g., the number of student stations). If it is desired to specify the expected class size, the following can be added:

> "The expected class size is______with ______students per student station/trainer."

In the blanks, the preparer must insert the expected class size and the number of students expected to use each station/trainer.

Background and Sources: The need for an Instructor Station and a Student Station is determined by reviewing paragraphs 5.3, 5.3.1, 5.3.2, 5.4, 5.4.1, and 5.4.2 of the ISD-Based Training Equipment Design. The Computational System, as a major component, can be divided into subcomponents. For example, the list can parallel the structure of subparagraph 3.7.2 and its subparagraphs. Some computer programs (software) can be derived by reviewing paragraphs and subparagraphs 5.2.1 through 5.2.9 of the ISD-Based Training Equipment Design Specification. Also see AFHRL-TP-84-49 paragraph 2.5.2.5 on component selection.

Lessons Learned: The subcomponents of the Computational System should be determined in conjunction with a computer expert (if possible). In any event, it is best to postpone completing this section of this subparagraph until the Computational System is well understood (i.e., in completing other paragraphs and subparagraphs, hints or ideas concerning the Computational System may come to mind).

The importance of modification programs (computer software) should not be forgotten. Software must be provided to facilitate the update of the simulation and instructional software and any data bases used by those programs. It must not be forgotten that the maintenance trainer, to be useful as an instructional device, must be kept current with the weapon system. This, typically, can be done only by guaranteeing that software can be easily modified to reflect the equipment or system being simulated. It may be appropriate to consider the Trainer Support System as a separate major component.

It is also advisable to seek assistance from computer software engineers concerning the subcomponents of the Instructional System Programs.

When specifying the components of the trainer, consideration should be given to using items which are in the DOD inventory; this will greatly influence the logistics considerations. However, sometimes the items in the DOD inventory are less than state-of-the-art. Thus, consideration must be given to the technology that the trainer must have, the initial cost of the component or item, the life-cycle cost of the component or item, and the availability of the item.

3.1.4 GOVERNMENT FURNISHED PROPERTY LIST.

> "The following items shall be furnished by the Government and shall be incorporated into and/or interfaced with the maintenance trainer by the contractor or vendor: ____________
> ____."

Rationale and Guidance: This subparagraph of the Prime Item Development Specification should be included only if the Government is going to provide the contractor or vendor with off-the-shelf items or equipment already in the Air Force inventory. These items, furnished by the Government, are often referred to as Government Furnished Equipment (GFE) or Government Furnished Property.

If off-the-shelf items or Government furnished items are to be supplied, the contractor or vendor must be aware of what items will be given or furnished. Furthermore, it should be made clear that the contractor or vendor is to have the responsibility to interface the furnished items with the maintenance trainer to the extent necessary for the operational use of the maintenance trainer.

Any item identified or listed in any of subparagraphs 3.1f, 3.1.2, and 3.1.3 of the Prime Item Development Specification that is to be furnished by the Government should also be listed in this subparagraph.

Be sure to list any support test equipment (to be furnished by the Government) that will interface with the maintenance trainer.

Performance Parameters: Enter any item that is to be furnished by the Government (including any support test equipment) that is to be incorporated into and/or interfaced with the maintenance trainer by the contractor or vendor. Also include any instructional equipment (e.g., random access slide projector) that is to be furnished by the Government and interfaced with the trainer.

If possible, any item identified in this subparagraph of the Prime Item Development Specification should be identified by reference to its nomenclature, specification number, and/or part number. All quantities of the Government furnished items must be completely specified.

MIL-T-81821 specifies that the following categories are appropriate for Government furnished items:

- End items and support equipment manuals.
- Government installed operational equipment.
- Contractor installed operational equipment.
- Common ground support equipment.
- Peculiar ground support equipment.

Subparagraphs 3.3.3, 4.2.1, 4.2.2, 4.2.3, 4.3.1.1, and 4.4 of the ISD-Based Training Equipment Design Specification should be reviewed when completing this subparagraph.

Background and Sources: This requirement is stipulated by MIL-STD-490 and MIL-T-81821. Also see AFHRL-TP-84-49 paragraph 2.1.2.8 for recommendations on the use of Government furnished hardware items.

Lessons Learned: Careful thought must go into the decision of which items shall be furnished by the Government. This decision should involve:

- The cost of the item(s).
- The reliability and maintainability of the item(s).
- The ease or difficulty of interfacing the item(s); e.g., often actual support test equipment cannot be easily interfaced with the trainer because of operating voltages.
- The fidelity level of the item(s). The ISD analyst now has procedures available for more precisely identifying the required levels of fidelity of components. If the Government is going to furnish items (standard or off-the-shelf items), then it is necessary to be certain that these items match the fidelity level indicated by the ISD analysis. In addition, care should be taken to assure that the off-the-shelf item has the required instructional capabilities (e.g., if an LRU is to be capable of malfunctioning, then an off-the-shelf LRU might not be appropriate).

3.1.5 GOVERNMENT LOANED PROPERTY LIST.

"The following items shall be loaned to the contractor or vendor by the Government: ________________________________
____."

Rationale and Guidance: This subparagraph should be completed only if item(s) are going to be loaned to the contractor or vendor by the Government.

Performance Parameters: Enter list of Government loaned property. The item to be loaned to the contractor or vendor should be referenced by its nomenclature, specification number, and/or part number. If the item is to be interfaced by the contractor or vendor, it should be so stated here.

Background and Sources: This requirement is stipulated by MIL-STD-490 (page 34).

Lessons Learned:

3.2 CHARACTERISTICS.

3.2.1 *PERFORMANCE.*

"The maintenance trainer (integration of all components) shall support maintenance training on ____________ system(s)/subsystem(s) of ____________."

Rationale and Guidance: This is a duplicate of the information entered in subparagraph 1.1 of the Prime Item Development Specification. This information is repeated here to assure that the information concerning the training objectives to be attained, the tasks to be acquired and/or practiced, and the malfunctions to be corrected and/or isolated on the maintenance trainer are put into proper perspective. That is, this statement becomes the terminal learning objective of the training program which will use the trainer. Restatement at this particular point in the Prime Item Development Specification will assure that the contractor or vendor has the intent of training specified when reviewing section 3.2 of the Prime Item Development Specification.

Performance Parameters: Enter the same information as was entered in subparagraph 1.1 of the Prime Item Development Specification.

Background and Sources: None available.

Lessons Learned:

3.2.1.1 TRAINING OBJECTIVES.

"The maintenance trainer shall be used to accomplish the following training objectives: ____________ ____________."

Rationale and Guidance: The training (learning) objectives to be attained using the proposed maintenance trainer greatly influence the design of the trainer. For the trainer to be acceptable it must be usable (by the students and instructor) to attain the specified learning objectives. If the training (learning) objectives are not attained by the students, then the maintenance trainer is not training effectively. It must not be forgotten that the purpose of the trainer is to train students.

In completing this subparagraph, one of two situations must be considered. The first case is where an ISD analysis has been completed and the specific training (learning) objectives have been clearly specified. The second instance is where an ISD analysis has not been completed and, therefore, part of the

effort is to have the contractor or vendor identify and state the specific training (learning) objectives.

In the situation where an ISD analysis has been performed or is in process, the information requested here can be directly obtained from the ISD-Based Training Equipment Design Specification or the appropriate subparagraphs from that document can be referenced; e.g., "The training objectives shall be as specified in subparagraph 2.5 of the ISD-Based Training Equipment Design Specification."

In the situation where an ISD analysis has not been performed, the contractor or vendor can be given this responsiblity via this specification, or a separate work order can be offered. If the contractor or vendor is given this responsibility, then this specification should spell out exactly what is required to attain the training (learning) objectives. A recommendation is offered below:

- Identification of the tasks performed by the AFSC of interest (on the job) using such sources as Logistical Support Analyses (LSAs), Technical Orders (T.O.s), Specialty Training Standards (STSs), interviews with operational and/or test personnel, etc. This step identifies the job requirements.

- Development of Task Descriptions (a list of the steps/ activities involved in the performance of the tasks).

- Analysis of the intended target population. (Before the learning objectives to be attained are specified, it is essential to know or specify the entering level of skill and knowledge of the target population.)

- Identification of the skills and knowledge required to perform the tasks previously identified.

- Identification of specific training requirements (i.e., training objectives). This is accomplished by subtracting the entry level behaviors from the job requirements.

- Selection of those training requirements (training objectives) to be practiced and/or acquired on the trainer. This decision is typically made by considering such issues as: whether or not the skill or knowledge is new to the target population, if it is difficult to learn, if there is a likelihood of performance error leading to possible personal injury or equipment damage, if there is a new or special tool, or test equipment required in order to display the intended behavior, etc.

For a complete reference on how the contractor or vendor can establish training (learning) objectives, see Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation.

Furthermore, if the contractor or vendor is given this responsibility, then this subparagraph of the Prime Item Development Specification should spell out how the task descriptions and training objectives should look; e.g.,

- Tasks shall contain an action verb and an object (to which the action is directed).

- Task descriptions shall contain all the steps/activities necessary to perform the task. All steps/activities should contain a verb and an object.

- Training objectives must contain a description of the behavior to be displayed by the trainee, the conditions under which this behavior is expected, and the criteria which will be used to judge successful attainment of the objective.

It is also worthwhile to note that if an ISD analysis has not been performed, then the contractor or vendor must also be given the responsibility to identify and specify the malfunctions to be isolated and/or corrected on the trainer, as well as determine the fidelity levels of the components on the trainer (these issues are discussed in other subparagraphs of this Handbook).

Performance Parameters: Either enter the specific training (learning) objectives directly from or by reference to subparagraph 2.5 of the ISD-Based Training Equipment Design Specification or specify the requirements the contractor or vendor must satisfy in developing the list of training (learning) objectives. It is not the intent of this Handbook to spell out all the requirements that the contractor or vendor must satisfy if the ISD analysis is not performed. The discussion offered above highlights the critical issues in establishing such requirements but should not be used verbatim in the specification. To specify these requirements completely, the preparer should be familiar with the content in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation and AFP 50-58, Handbook for Designers of Instructional Systems.

Background and Sources: This requirement is a clarification of the criteria implied in MIL-STD-490 and MIL-T-81821. As stated, this is a new requirement. Also see AFHRL-TP-84-49 paragraph 2.1.2.9 on the need for training information.

Lessons Learned: The set of training objectives specified is the foundation of the design of the training equipment. It has been found that the objectives must be stated clearly and precisely. It is currently the trend to consider evaluating the training effectiveness of developed maintenance trainers against the training (learning) objectives. Implementation of this training effectiveness approach depends upon having clearly stated training objectives. Even though the trainer meets all the requirements specified in the Prime Item Development Specification, if it does not have the capability to accomplish the specified training objectives, then the trainer has little or no utility as a training tool. It should not be forgotten that the trainer is being built to train students. Thus, the training or learning objectives are critical to the design of the trainer. In terms of accepting the trainer, the trainer must be usable by instructors to achieve the desired training objectives. If the trainer fails to train the desired objectives, then the design effort has been a failure. In fact, during acceptance testing, the maintenance trainer should be assessed for its ability to meet the specified training objectives.

3.2.1.2 TASKS TO BE TRAINED.

"The following tasks and/or part-tasks shall be practiced and/or acquired on the maintenance trainer: ________________ ____."

Rationale and Guidance: It is essential for the contractor or vendor to clearly understand what specific task performances will be practiced and/or acquired using the intended maintenance trainer. There should be close correspondence between the tasks listed in this subparagraph and the training objectives specified in subparagraph 3.2.1.1 of the Prime Item Development Specification; i.e, the list provided in this subparagraph supplements and clarifies the list supplied in that subparagraph.

Notice that the item stem includes part-tasks. Often maintenance trainers are designed to promote acquisition and/or practice of part of a task and not necessarily the whole task. If only part of a task is to be practiced and/or acquired, it is advisable to specify the whole task and clearly indicate which part of the task is to be acquired and/or practiced on the proposed maintenance trainer. This information will be useful to the contractor or vendor.

Performance Parameters: Enter the list of tasks and part-tasks to be acquired and/or practiced on the proposed maintenance trainer. The tasks should be stated in accordance with the guidelines specified in AFP 50-58, Volume II (pages 2-10 to 2-12).

If an ISD analysis has been performed according to the procedures specified in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation, then the task list will be found in subparagraph 2.4.1 of the ISD-Based Training Equipment Design Specification.

If an ISD analysis has not been performed, then this subparagraph should contain the requirements necessary for the contractor or vendor to identify such tasks and/or part-tasks. These requirements (e.g., what the task statements should look like) can be obtained from either AFP 50-58, Volume II (pages 2-10 to 2-12) or from Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation. If the ISD analysis has not been done, it is necessary to assure that the contractor or vendor properly identifies and documents those tasks and part-tasks to be acquired and/or practiced on the proposed maintenance trainer from all the tasks associated with the AFSC of interest. This requirement can be stated as:

> "The contractor or vendor shall select from the population of identified tasks only those tasks and part-tasks that empirical studies conclude must be acquired and/or practiced on a maintenance trainer or shall develop a list of criteria for selecting such tasks and part-tasks and employ that list of criteria only upon approval of the procuring activity."

It is also recommended that a specific T.O. be referenced beside each task or part-task that is identified. These will assist the contractor or vendor in designing the maintenance trainer. The T.O.s referenced in this subparagraph of the Prime Item Development Specification should also be listed in subparagraph 2.0 of the specification; i.e., these T.O.s should be part of the applicable documents which the contractor or vendor should review when designing the trainer. For clarity the information might be Presented in table form.

TASK TITLE	REFERENCE SOURCES (e.g., T.O.)

For an additional example of such a completed form see Specification No. 16PS039B.

Background and Sources: This requirement is a further clarification of criteria specified in MIL-STD-490 and MIL-T-81821.

Lessons Learned: Maintenance tasks can be categorized into three types: operational checks, remove/replace, and troubleshooting. Of the three, troubleshooting is the predominant task taught in most maintenance training simulators. For the simulators studied in a recent survey, an average of 50 percent of student task time was spent on troubleshooting.[4] The type of task to be trained will affect the decision to use simulator training, as well as the design of the trainer. This is also evidenced in the following subparagraph.

3.2.1.3 MALFUNCTIONS TO BE SIMULATED.

"The maintenance trainer shall present and/or simulate the following classes or categories of malfunctions: ____________ ____."

Rationale and Guidance: The greater part of maintenance training consists of isolating and/or correcting malfunctions or faults. This subparagraph is included to establish which malfunctions the trainer must present to the students (either for isolation or correction).

It should be noted that the training objectives specified in subparagraph 3.2.1.1 should contain behaviors to isolate and/or correct specific malfunctions; thus, this subparagraph supplements that subparagraph and further clarifies for the contractor or vendor exactly what malfunctions must be presented by the proposed maintenance trainer.

Performance Parameters: Enter the list of malfunctions to be presented by the proposed maintenance trainer. If an ISD analysis has been done then enter, either directly or by reference, the content the ISD analyst entered in subparagraph 2.4.2 of the ISD-Based Training Equipment Design Specification. Often a class of malfunction symptoms can be isolated to one, two, or three faulty items or parts. If the trainer is to present malfunction symptoms, the instructor may want the trainer to offer a menu of possible items or parts which would cause the malfunction. Thus, when specifying the malfunctions to be presented, the preparer may find it convenient to associate each malfunction with a set of possible faulty parts or items. Some instructors, however, feel that to specify a number of fixes

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[4] Carroll, R. J., Thocher, L. T., Roth, J. T., and Massey, R. H. Maintenance simulators: Their use, cost, and perceived effectiveness. AFHRL-TR-84-53 Lowry Air Force Base, Colorado: Training Systems Division. 1985

limits the flexibility of the trainer. These instructors would prefer the capability to select not only the class of malfunctions to be presented as an exercise, but also the class of fixes. If this is desired, it should be so stated in this subparagraph.

If an ISD analysis has not been performed, then this subparagraph of the Prime Item Development Specification must establish how the contractor or vendor is to identify such malfunctions, as well as specify the criteria for selecting those malfunctions.

The contractor or vendor should identify the population of possible malfunctions following the procedures in either AFP 50-58 (Volume II, Chapter 2) or Maintenance Training Simulator Design and Acquisition - Handbook of ISD Procedures for Design and Documentation (Chapter 3). The following wording might be used to establish these requirements:

> "The contractor or vendor shall identify and record all classes or categories of malfunctions of ____________________ system(s)/subsystem(s) of ____________________."
>
> "The contractor or vendor shall identify all classes or categories of malfunctions without regard to whether the malfunctions are identifiable through the built-in tests or self-test mechanism of the operational equipment."
>
> "All identified malfunctions shall be recorded and documented on decision flow charts, indicating what sources of the malfunctions can be eliminated at what points. All malfunctions specified and recorded shall lead to a single Line Replaceable Unit (LRU), unless otherwise specified herein."

The documentation of the malfunctions should be made a deliverable item.

The above wording specifies requirements for selecting the malfunctions, if and only if, the contractor or vendor is given the responsibility to identify and select the malfunctions. Typically, malfunction identification and selection are performed by the ISD analysts. If the contractor or vendor is given the responsibility, because of the acquisition cycle, it would behoove the contractor or vendor to consult with a subject matter expert when developing the list of malfunctions. In addition, the contractor or vendor should use the Organizational Maintenance Manual - 2 series document as a background/reference source when compiling a list of malfunctions.

The requirements above state that the malfunctions selected for presentation should lead to a Line Replaceable Unit (LRU). It may be that, in a particular application, going to an LRU may not be sufficient. It depends upon the training requirements and objectives. In an advanced course, troubleshooting may be required beyond the LRU level. If the current application is to provide practice beyond the LRU level, it should be so stated within this subparagraph.

For some advanced courses, it may be appropriate for the trainer to simulate multiple malfunctions. If this is desired, then the preparer must make it clear that the trainer is to be capable of presenting multiple malfunctions. There are two ways to specify the multiple malfunction requirement. The first way simply requires any malfunction to be presented with any other malfunction. The following words might be used:

> "The trainer shall present multiple malfunctions; i.e., multiple malfunctions can be selected by the instructor as any pairs of single malfunctions."

The second way is, perhaps, more complex. It may be that the operating equipment typically fails in certain ways; i.e, one malfunction is usually associated with another malfunction. If certain malfunctions occur in pairs on the operational equipment, then the instructor may want only these pairs to be represented to the student. If this type of multiple malfunction is required, then the preparer should list the pairs.

In selecting those malfunctions to be presented and/or simulated on the proposed maintenance trainer, the contractor or vendor (if he is assigned the responsibility to select the malfunction) should be given the following criteria.

> "The contractor or vendor shall select a set of malfunctions from the population of possible malfunctions using the following criteria:
>
> a. The selected set of malfunctions shall be representative of the population of possible malfunctions. This shall range from simple to complex. Simple malfunctions can be used for demonstration purposes. Complex malfunctions can be used for advanced classes. Complex malfunctions require an understanding of system and hardware logic.
>
> b. The selected set of malfunctions shall represent those malfunctions that occur in the operational weapon system.

c. At least two malfunctions from each malfunction class shall be selected (one for learning and one for testing the learner at the end of instructional units, modules, or courses).

d. The selected set of malfunctions shall not be trivial in nature (i.e., the set of selected malfunctions shall include malfunctions isolated following existing T.O.s as well as malfunctions which have not been proceduralized in T.O.s). The contractor or vendor should not derive the malfunctions simply from existing publications (fault reports and fault isolation manuals). It is important for the contractor or vendor to glean malfunctions through computational forecasting of projected real-time failures.

e. Isolation of the malfunctions selected shall involve knowledge (from the student) of system logic and hardware logic."

It should be recalled that if an ISD analysis has been performed, subparagraph 2.4.2 of the ISD-Based Training Equipment Design Specification will include the list of malfunctions that the trainer must present. That is, the ISD analyst will not only identify the malfunction, but select those that must be presented by the trainer. If given this responsibility, the contractor or vendor should follow the same procedure that the ISD analyst would use.

Whether an ISD analysis has been performed or the contractor or vendor is to identify the malfunctions to be isolated and/or corrected, provisions should be made for identifying malfunctions which might be added in the future; i.e., malfunctions which can be added to the trainer's repertoire in the future. Often the malfunction capability of the trainer is limited, and instructors, after using the maintenance trainer for a while, often wish to add new malfunction isolation exercises. This often becomes an expensive effort and usually requires going back to the original contractor or vendor. This expense can be minimized if the trainer (when it is designed) is given the capability to present new malfunctions. In addition, if these new or additional malfunction capabilities are designed into the trainer, then the Air Force will not be locked into the original contractor or vendor (as long as documentation is provided by the contractor or vendor on how to activate these malfunctions). Thus, consideration should be given to adding the following items in this subparagraph:

a. "The maintenance trainer shall have the capability to present and/or simulate the following malfunctions in the future: ______________________________ ____________________ (provide list).

b. The malfunctions specified above shall be made operational by activating switches, making electrical connections, by expanding existing data bases, or by other methods which require only minimal skill and knowledge other than technical knowledge of the device or system being simulated.

c. The contractor or vendor shall provide documentation on how these additional malfunctions are activated. This documentation shall be proceduralized and presented in a step-by-step fashion. All activation procedures shall require only standard tools and equipment and shall not require replacement of components or items.

d. All activation procedures shall be designed to be performed by Air Force personnel with the following qualifications: ________________________________ (list qualifications)."

If an ISD-Based Training Equipment Design Specification has been prepared by the ISD analyst, then completion of the above items can be accomplished by examining subparagraph 3.2.1.3 of the ISD-Based Training Equipment Design Specification. If an ISD analysis has not been performed, then the contractor or vendor must be given this responsibility; e.g.,

"The contractor or vendor shall identify a set of malfunctions which can be easily activated in the future as well as provide the trainer with the capability of presenting these malfunctions."

The contractor or vendor should then be required to follow the requirements specified in items b through d above.

All documentation of the activation procedures should be made deliverable items.

As an alternative to specifying the above requirements, it has been suggested that for future malfunctions only spares be provided. It is important to make provisions for spares, but it is also important to specify as much as possible about the future malfunctions since the expected or anticipated malfunction may influence the design of the trainer.

It is understood that it is difficult to foresee the future, but this requirement attempts to avoid some of the problems experienced in the past. Currently, there are no procedures available for predicting what kind of malfunctions may be desired

c. At least two malfunctions from each malfunction class shall be selected (one for learning and one for testing the learner at the end of instructional units, modules, or courses).

d. The selected set of malfunctions shall not be trivial in nature (i.e., the set of selected malfunctions shall include malfunctions isolated following existing T.O.s as well as malfunctions which have not been proceduralized in T.O.s). The contractor or vendor should not derive the malfunctions simply from existing publications (fault reports and fault isolation manuals). It is important for the contractor or vendor to glean malfunctions through computational forecasting of projected real-time failures.

e. Isolation of the malfunctions selected shall involve knowledge (from the student) of system logic and hardware logic."

It should be recalled that if an ISD analysis has been performed, subparagraph 2.4.2 of the ISD-Based Training Equipment Design Specification will include the list of malfunctions that the trainer must present. That is, the ISD analyst will not only identify the malfunction, but select those that must be presented by the trainer. If given this responsibility, the contractor or vendor should follow the same procedure that the ISD analyst would use.

Whether an ISD analysis has been performed or the contractor or vendor is to identify the malfunctions to be isolated and/or corrected, provisions should be made for identifying malfunctions which might be added in the future; i.e., malfunctions which can be added to the trainer's repertoire in the future. Often the malfunction capability of the trainer is limited, and instructors, after using the maintenance trainer for a while, often wish to add new malfunction isolation exercises. This often becomes an expensive effort and usually requires going back to the original contractor or vendor. This expense can be minimized if the trainer (when it is designed) is given the capability to present new malfunctions. In addition, if these new or additional malfunction capabilities are designed into the trainer, then the Air Force will not be locked into the original contractor or vendor (as long as documentation is provided by the contractor or vendor on how to activate these malfunctions). Thus, consideration should be given to adding the following items in this subparagraph:

a. "The maintenance trainer shall have the capability to present and/or simulate the following malfunctions in the future: ______________________________ ______________________ (provide list).

b. The malfunctions specified above shall be made operational by activating switches, making electrical connections, by expanding existing data bases, or by other methods which require only minimal skill and knowledge other than technical knowledge of the device or system being simulated.

c. The contractor or vendor shall provide documentation on how these additional malfunctions are activated. This documentation shall be proceduralized and presented in a step-by-step fashion. All activation procedures shall require only standard tools and equipment and shall not require replacement of components or items.

d. All activation procedures shall be designed to be performed by Air Force personnel with the following qualifications: ______________________________ (list qualifications)."

If an ISD-Based Training Equipment Design Specification has been prepared by the ISD analyst, then completion of the above items can be accomplished by examining subparagraph 3.2.1.3 of the ISD-Based Training Equipment Design Specification. If an ISD analysis has not been performed, then the contractor or vendor must be given this responsibility; e.g.,

"The contractor or vendor shall identify a set of malfunctions which can be easily activated in the future as well as provide the trainer with the capability of presenting these malfunctions."

The contractor or vendor should then be required to follow the requirements specified in items b through d above.

All documentation of the activation procedures should be made deliverable items.

As an alternative to specifying the above requirements, it has been suggested that for future malfunctions only spares be provided. It is important to make provisions for spares, but it is also important to specify as much as possible about the future malfunctions since the expected or anticipated malfunction may influence the design of the trainer.

It is understood that it is difficult to foresee the future, but this requirement attempts to avoid some of the problems experienced in the past. Currently, there are no procedures available for predicting what kind of malfunctions may be desired

in the future. However, it is perhaps reasonable to suggest that the experiences of the ISD analyst and the SPO engineer might provide insights into what sorts of malfunctions will be needed in the future. For example, a review of past maintenance trainer development projects might provide insight into the class or category of malfunctions that the instructors might require in the future. In addition, ISD analysts who are close to the operational equipment might be able to speculate how the operational equipment might change. Thus, they might be in a position to offer suggestions about how the operational equipment will malfunction in the future.

Background and Source: This is a further clarification of paragraph 20.3.2.1 of MIL-STD-490 and paragraph 3.2.1.1 of MIL-T-81821. The identification of future malfunction exercises is a new requirement.

Lessons Learned: Often the contractors or vendors were given the responsibility to select the malfunctions to be presented and/or simulated. The contractors or vendors tended to select malfunctions based on how easy it would be to simulate those malfunctions. As a result, the malfunctions simulated and/or presented by the trainer were not representative. Often, the selected malfunctions were extremely similar, thereby restricting the utility of the maintenance trainer in terms of training. For example, the student usually does not need five or six exercises to practice isolating faulty fuses, if the isolation procedures are extremely similar. In addition, contractors or vendors selected malfunctions which were considered trivial; e.g., involving following procedures specified in T.O.s. Often instructors want to use the maintenance trainer to develop troubleshooting skills (i.e., the ability to isolate faults) when T.O. procedures are not available or have not been developed. Such troubleshooting involves an understanding of both hardware and software logic. The requirements specified above are an attempt to overcome these fault selection problems.

It has been discovered, through experience, that it is not a good idea to designate a number requirement in the specification; e.g., "The contractor or vendor shall design the trainer to present and/or simulate ten malfunctions." Such requirements inhibit selecting the most representative sample of malfunctions or inhibit selecting those malfunctions which truly match the job requirements.

Furthermore, one of the problems experienced in the past has been the inability to add new malfunctions. The need to add malfunctions has often forced the Air Force to go back to the original contractor or vendor. Also, in most cases, programming skills were required in order to add new malfunctions. Thus,

provisions should be made for allowing new malfunction exercises to be created with a minimum of effort and expense. An attempt has been made in this document to do exactly this. Although the wording for expressing this requirement is, perhaps, vague, as are the procedures available for making such predictions, the intent here is to inform the contractor or vendor that the Air Force desires the trainer to have the capability to expand the possible list of malfunctions with little effort.

Many recent simulators (post-1981) have the capacity for malfunction insertion via computer generation or pretaped cassettes. The computer-generated fault capability often allows for an unlimited number of faults. This capability allows for future addition of malfunctions, helping to make the simulator cost effective. In a recent survey, malfunction insertion/update was almost unanimously favored by maintenance training instructors.

3.2.1.3.1 MAINTENANCE CONCEPT OF OPERATIONAL EQUIPMENT.

"The maintenance concept of the equipment being simulated is ____."

Rationale and Guidance: The training objectives, tasks, and malfunctions to be isolated must be put in perspective. It may help the contractor or vendor to understand these better if a clear description of the maintenance concept of the operational equipment is given. Note this is not the maintenance concept associated with maintaining the trainer, it is the maintenance concept associated with the operational equipment being simulated.

Performance Parameters: Enter the maintenance concept associated with the operational equipment. This description should be brief and concise. This description, as a minimum, should include a definition and use statement of organizational-, intermediate-, and depot-level maintenance. It may even be advisable to specify which of these groups are targeted to use the maintenance trainer. If the trainer is to be used by multiple levels, the preparer should so state in this subparagraph. Notice that this is not a requirement. This paragraph is included only to provide guidance to the contractor or vendor.

Background and Sources: This is not a requirement. The information is provided as guidance only.

Lessons Learned: In the past, there have been instances of fidelity "overkill"; i.e., the trainer has been designed at a higher level than that actually required. Although the ISD analyst now has tools available to help in determining the most

appropriate level of fidelity, it is important that the maintenance concept be fully described. The maintenance concept description will help the contractor or vendor put the levels of fidelity specified herein in proper persp ctive. In addition, if the contractor or vendor is given the responsibility to determine the level of fidelity, then the maintenance concept will help to accomplish this task. It is probable that the fidelity overkill experienced in the past is partially due to the inadequate definition of the maintenance concept. Thus, the maintenance concept of the operational equipment must be clearly defined. In a generic specification such as this, it is difficult to prepare a standard definition of the maintenance concept of the operational equipment being simulated. Thus, the preparer must supply this information.

3.2.1.4 FIDELITY LEVELS

"The represented system's components shall be physically and functionally simulated to the extent required to meet the training objectives, as specified in subparagraphs 3.2.1.1, 3.2.1.2, and 3.2.1.3 herein. The level of fidelity required is further specified in the paragraph below."

Rationale and Guidance: This subparagraph requires no input from the preparer; i.e., it contains no blanks. This subparagraph is to serve as an advanced organizer for the next two subparagraphs. The intent of this subparagraph is to inform the contractor or vendor that the systems and/or subsystems being simulated must be simulated to the degree that the training objectives can be achieved, that the tasks targeted for practice can be effectively practiced, and that the specified malfunctions can be effectively isolated and/or corrected. It should be noted that this subparagraph does not leave the contractor or vendor with the responsibility to determine the fidelity level. The fidelity level of the trainer is actually determined by the ISD analysts. The fidelity level(s) determined by the ISD analysts are communicated in the Prime Item Development Specification via the next two subparagraphs of the specification.

Performance Parameters: No input is required of the preparer.

Background and Sources: See AFHRL-TP-84-49 paragraph 2.7.2.1 for information on logistics support factors associated with fidelity levels.

Lessons Learned: This subparagraph and the next two subparagraphs are designed to describe the functional, psychological, and physical fidelity levels of the components or parts to be on the trainer. These subparagraphs are designed to eliminate the "overkill" that might occur when designing and building a maintenance trainer.

3.2.1.4.1 FIDELITY LEVELS OF SIMULATED EQUIPMENT.

"a. The displays, controls, indicators, LRUs, etc. specified in subparagraphs 3.1f and 3.1.3, herein, shall have the physical and functional characteristics specified in this subparagraph: ______________________ ____."

"b. The system(s)/subsystem(s) being simulated shall sense the activation of controls and provide corresponding output displays or indications as specified in subparagraph 3.2.1.4.1a of this specification. The system(s)/subsystem(s) shall be simulated to allow the operation of the system(s)/subsystem(s) without insertion of any special lesson procedures unless otherwise stated herein."

Rationale and Guidance: The purpose of this subparagraph is to establish, as requirements, the physical and functional characteristics of the components (subcomponents, parts, LRUs, etc.) being represented on the trainer. The components (and subcomponents) have been listed in subparagraphs 3.1f and 3.1.3 of the Prime Item Development Specification. Each of the components and subcomponents listed in these subparagraphs should be addressed in this subparagraph. That is, each component and/or subcomponent to be simulated must be described in this subparagraph.

Furthermore, if support equipment (e.g., test equipment) is to be simulated, it is essential to specify the characteristics (both physical and functional) of the support equipment and/or any of its components (such as displays, controls or indicators) in this subparagraph.

Performance Parameters: Enter the physical and functional characteristics of each of the components and/or subcomponents identified in subparagraphs 3.1f and 3.1.3 of the Prime Item Development Specification. Include the functional and physical characteristics of any support equipment which is to be simulated. Consider having two subparagraphs within this paragraph: one for the simulated equipment and one for Support Equipment (e.g., 3.2.1.4.1.1 SIMULATED EQUIPMENT and 3.2.1.4.1.2 SUPPORT EQUIPMENT).

When determining the physical characteristics of components to be simulated, consider the following factors:

- Size (relative size).
- Shape (and/or texture).
- Color.
- Weight.

- Center of gravity.
- Physical position relative to other components or subcomponents.

These factors should be considered only in light of the influence they have on the student, in terms of transfer of training. A subcomponent (display, control, or LRU) must be the same shape as the real subcomponent only if the shape of the subcomponent serves as a stimulus, response, or feedback to the student.

The functional characteristics to consider are:

- Control/display ratios (control sensitivity).
- Interrelationship or dependency among display functions.
- Dependencies among controls.
- Visual or physical feedback provided.

Again, these functional characteristics should be listed only if they impact upon the student as stimuli, responses, or feedback. If an ISD-Based Training Equipment Design Specification has been prepared by the ISD team, the fidelity level decision will already be made (i.e., these characteristics will already have been identified). These decisions will be recorded in subparagraphs 4.3.1 and 4.3.1.1 of the ISD-Based Training Equipment Design Specification.

The preparer might also find it useful to include sketches, line drawings, and/or pictures of the equipment being simulated. However, these should be included only as suggestions and not necessarily as requirements.

If an ISD analysis has not been performed, then the contractor or vendor must be given the responsibility to determine the fidelity levels of the simulated equipment. The contractor or vendor should be given guidance on how this might be accomplished as well as the requirement that the level of fidelity must be such that the training objectives, tasks, and malfunctions can be attained, practiced, and/or acquired. Consider the following wording:

> "The contractor or vendor shall identify those characteristics of the actual equipment and support equipment that need to be represented to accomplish the training objectives, to practice and/or acquire the tasks and to isolate and/or correct the malfunctions specified herein. These characteristics shall be identified according to the procedures specified in ______________________________ ______________________ (document name)."

One possible source document is Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation (Step 6).

If the contractor or vendor is given this responsibility, then all documents generated from whatever procedure is specified should be made deliverable items.

Background and Sources: This requirement is a further clarification of paragraph 20.3.2.1 of MIL-STD-490 and paragraph 3.2.1.1 of MIL-T-81821.

Lessons Learned: Often high-level fidelity is decided on when low fidelity would have been sufficient and just as effective. To sharpen the fidelity-level decision a procedure was developed and documented in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation.

To illustrate the point concerning the importance of fidelity levels and to provide some evidence that high fidelity is not always better, consider the following lesson learned which was submitted when this document was being prepared:

> ". . . In developing Maintenance Training Simulators, it is usually assumed that increases in physical fidelity will result in increases in the training effectiveness of the device. In trainers with high physical fidelity, slight increases in physical fidelity may entail very large costs that are difficult to justify. The intent here is to suggest that, at times, these increases may not only be unjustifiable, they may actually result in a decrease in the training value of the device."

> ". . . When the physical fidelity of a trainer approaches that of the actual equipment, minor discrepancies become apparent and bothersome. At times, these discrepancies can be overcome more efficiently by reducing the fidelity to the point where the discrepancy becomes obvious and harmless rather than attempting to eliminate it."

> ". . . During the formative evaluation of Maintenance Training Simulators, discussions with students and instructors often reveal defects that appear on the surface to be minor and yet the user may object strenuously to them. Examples would be test points that do not look like the one in the actual equipment, switches that do not 'feel' right, lights that come on too fast or too slow, or connectors on cables that are different. Some of these are easy to correct, others are deceptively difficult and expensive. In one situation where there is a series of trainers that vary in physical fidelity, it has been observed that as long as the user realizes that the object is only intended to 'represent' a part on the actual equipment and that it was not intended to 'be like' the actual part, he will accept it. It is as though they will accept caricatures of equipment,

but not poor replicas. As an example, in one instance the student was required to test the output at a series of test points. The design of the trainer called for a meter to indicate the output. On the actual equipment, an oscilloscope would be used for this measurement and the instructors were reluctant to accept the meter, since they felt it would result in negative instructions; i.e, teach the student to use incorrect test equipment. Meters were used in other tests, but not this particular one. Redesigning the trainer to generate signals compatible with oscilloscopes would have been expensive. Substituting a series of indicator lights labeled '-15 volts, pulsed,' etc. was acceptable to the instructor since it was obviously artificial and the student would not be confused or mistaught. The objection to inadequate physical fidelity was overcome by using less physical fidelity rather than more."

". . . When minor defects in physical fidelity are encountered and it would be difficult to increase the fidelity, consider backing off to a point of less fidelity to overcome the defect. Psychological fidelity is often considered to be merely a 'cop out' to justify a reduction in funds. This is not always the case. At times, psychological fidelity can be increased by a decrease in physical fidelity and this increase can result in an increase in the training value of the device. The goal should be to obtain a device that trains in the intended way, not one that necessarily looks like the actual equipment."

It is important for the Program Manager to monitor the fidelity level of the trainer as it is being developed. The fidelity Levels of the components or parts should be checked against this section of the specification. The Program Manager should be careful that the fidelity levels of the components or parts of the trainer do not change as the trainer is being built. It is important to monitor the fidelity level, since the fidelity level impacts on the usability of the trainer for training purposes.

3.2.1.4.2 ENVIRONMENTAL FIDELITY.

"The following aspects of the job-performance environment shall be simulated: ______________________________
______________________________."

Rationale and Guidance: When designing a maintenance trainer, it is important to specify not only the characteristics of the equipment being simulated but also the environmental conditions or factors which must be simulated; e.g., if the maintenance trainer must be configured as a cockpit or if it must simulate the working environment of an outdoor field unit, such as extreme temperature or loud ambient noise.

Performance Parameters: When specifying the job-performance environment to be simulated, consider the following factors:

- Ambient noise levels (specify in dBA).
- Ambient air conditions (e.g., specify temperature in Centigrade degrees.).
- Team work (e.g., specify location of team members).
- Student-to-student communication (e.g., specify how such communication is to be made).

Include only those environmental conditions which it is essential represent or replicate. These can be identified only by careful analysis of the actual job requirements. For example, if the job requires the student to detect and/or identify tones in a typically noisy environment, it might be appropriate to simulate the ambient noise level in the training situation. This will certainly increase transfer of training.

Many of the environmental conditions that need to be simulated can be identified by examining the conditional phrases in the specified training objectives (see subparagraph 3.2.1.1 of the Prime Item Development Specification for a list of the training objectives). Also see subparagraphs 3.3.1, 3.3.2, 4.3.2, 6.2, and 6.3 of the ISD-Based Training Equipment Design Specification for the information prepared by the ISD analysts.

It is also important to specify any job aids or materials that the student will be allowed to use in the job environment and therefore allowed to use in the training environment. Such job aids or materials should be considered part of the simulated environment. For a list of the job aids see subparagraphs 3.3.3 and 3.3.4 of the ISD-Based Training Equipment Design Specification.

Background and Sources: This is a new requirement.

Lessons Learned: AFHRL-TP-84-49 paragraph 2.4.2.9 suggests that simulation of environmental noise could interfere with training.

3.2.1.4.3 PROBABLE ENGINEERING CHANGES.

"a. Any engineering change for the system or subsystem being simulated, specified in an engineering change proposal (ECP) up to and including changes proposed as of _______ ___________, shall be incorporated into the trainer. After this date, the trainer shall be included as part of the system or subsystem equipment ECPs."

"b. The maintenance trainer shall be designed to accommodate the possible and probable engineering changes specified within this subparagraph: ______________________________ ____."

As can be seen, this subparagraph has two items. For convenience each item is discussed separately; i.e., each item has its own Rationale and Guidance, Performance Parameters, Background and Sources, and Lessons Learned sections.

"a. Any engineering change for the system or subsystem being simulated, specified in an engineering change proposal (ECP) up to and including changes proposed as of ________________, shall be incorporated into the trainer. After this date, the trainer shall be included as part of the system or subsystem equipment ECPs."

Rationale and Guidance (Item *a*): Item *a* of this subparagraph is included in the Prime Item Development specification to indicate that the contractor or vendor will be responsible for incorporating into the maintenance trainer any engineering changes for the system or subsystem being simulated that are specified by an engineering change proposal. When the trainer is being developed, often the system or subsystem being simulated is in a state of evolution. To guarantee that the trainer remains current with the system or subsystem being simulated, the trainer contractor or vendor must be responsible for incorporating into the trainer any system or subsystem changes. To protect the Air Force and the contractor or vendor, a final date must be specified for the engineering changes that are to be incorporated into the maintenance trainer. The blank in item *a* provides the preparer an opportunity to specify this date.

It should be noted that item *a* also specifies or informs the contractor or vendor that after the specified date any changes to the system or subsystem will be accompanied by an ECP for the changes in the trainer. If the trainer contractor or vendor is the same as the weapon system contractor or vendor, then one ECP may be sufficient for the weapon system and the trainer.

Performance Parameters (Item *a*): Enter a specific date (e.g., "September 12, 1985") or an event date (e.g., "Two months before the scheduled acceptance test).

Background and Sources (Item a): Item a does not represent a requirement established by any Military Standard or Specification. The date entered in the blank depends upon the nature and time of the specific project.

Lessons Learned (Item a) The acquisition cycle of trainers often means that the system or subsystem being simulated is in a state of change (evolution). Because the system or subsystem being simulated is changing, it is difficult to keep the design of the trainer current. One way to assure this is to specify that the contractor or vendor has the responsibility to incorporate system or subsystem ECPs into the trainer while the trainer is being designed and developed. It should be mentioned, however, that not all system or subsystem equipment ECPs will affect the trainer. Many ECPs made to the equipment being simulated are not critical to the training mission. For example, a system change that decreases a response time by 0.05 second may not be critical to include into the trainer. Although the requirement stated above requires the contractor or vendor to incorporate all ECPs into the trainer, this requirement may be unnecessarily restrictive. If the preparer is uncomfortable with requiring the contractor or vendor to incorporate all ECPs into the trainer, then the preparer may find it necessary to specify the nature of the ECPs that should be incorporated into the trainer by the contractor or vendor. For example, the preparer may insert the following after item a:

> "Any engineering change to the system or subsystem being simulated specified in an engineering change proposal, which the contractor or vendor can justify as not impacting upon the training mission as specified herein, shall be submitted in writing to the procuring activity for consideration."

As an alternative to the above wording, the preparer may explicitly state the criteria for incorporating the ECP into the system or subsystem being simulated. For example, consider the following wording:

> "ECPs which do not directly affect the training mission as specified herein need not be incorporated into the trainer. Changes which are candidates for non-corporation shall include, but not be limited to:
>
> - The changing of a position of a display or control if that display or control is not required during the training.

- The changing of a parameter value if the change does not affect the performance of the learning objectives."

Thus, the preparer has three options:

1. To state that <u>all</u> ECPs must be incorporated.

2. To specify that the contractor or vendor must submit in writing those ECPs which are not to be incorporated, providing such omissions can be justified.

3. To specify the criteria for non-incorporation.

It has been suggested that another method be used for incorporating ECPs into the trainer. This method consists of dividing the acquisition cycle into two distinct phases. The first phase would consist of ECPs identified between the acquisition contract award date and the critical design review (CDR). The second phase would consist of ECPs identified between CDR and the physical and functional configuration audits (acceptance). The trainer could be "drop shipped" to the contractors or vendors, and the second group of ECPs could be incorporated prior to delivery to the user. In this respect, the delivery of the trainer would be close to the current aircraft configuration. This notion for program management control is reasonable and can be incorporated into the current subparagraph by simply specifying, in the blank of item <u>a</u>, the delivery date to the user. However, this solution does not affect the need to consider screening the ECPs. Not all ECPs would impact training. Thus, it is still advised that this subparagraph contain some requirements for justifying which ECPs should be incorporated into the trainer.

"b. The maintenance trainer shall be designed to accommodate the possible and probable engineering changes specified within this subparagraph: ______________________________ ____."

<u>Rationale and Guidance</u> (Item b): This item is designed to provide guidance to the contractor or vendor when specific changes are anticipated.

Since maintenance trainers are designed early in the weapon system acquisition cycle, many engineering changes in the actual equipment can be expected. If these possible engineering changes can be predicted, then it might be possible for the contractor or vendor to design the trainer in such a way that these possible changes can be easily made, thus keeping the trainer current with the operational equipment. For example, if the location of a

display or control is expected to change, then this information might allow the contractor or vendor to consider designing the display or control so that it can be easily removed or easily relocated (e.g., as a modular component). Functional changes may be more difficult to predict or identify.

It is understood that it is extremely difficult to speculate about possible and probable engineering changes. However, ISD analysts familiar with similar systems or subsystems may be able to speculate about some possible changes. In fact, the ISD analysis itself may reveal possible areas where changes should take place. Furthermore, engineers with experience (with previous weapon systems) may also be able to speculate about possible changes. Experience may indicate that some sort of changes in a particular area are highly likely. It should be stressed that what is inserted here is not to be interpreted by the contractor or vendor as a given. The information is provided only as guidance to the contractor or vendor.

Performance Parameters (Item b): Consider the following factors:

- Location of display/control (specify display/control and possible new location).
- Addition of new displays/controls (specify the locations and functions of the additional displays/controls).
- New control/display ratios (specify anticipated ratio).

See subparagraph 4.3.3 of the ISD-Based Training Equipment Design Specification for the possible engineering changes expected by the ISD analysts.

Background and Source (Item b): This is a new requirement. See AFHRL-TP-84-49 paragraph 2.7.2.11 for information on logistical factors associated with engineering changes.

Lessons Learned (Item b): Keeping the maintenance trainer current (up-to-date) can be expensive and time-consuming. In addition, the contractor or vendor has available many methods and materials which can be used, are easy to modify or update, and are relatively inexpensive to implement; e.g.,

- Stick-on labels instead of photo etching.
- Modularization of units or components.

Identification of the areas where probable engineering changes can or might occur will help the contractor or vendor determine where such materials as those specified above might be used.

3.2.1.5 INSTRUCTIONAL CAPABILITIES.

"The trainer has several instructional capabilites based upon the training objectives specified herein. The trainer shall:

____

_______________________________________."

Rationale and Guidance: Instructional features on maintenance trainers are a relatively new idea and area. This subparagraph provides an opportunity to record or specify the features that are desired. This subparagraph is only an advance organizer; the subparagraphs which follow in the Prime Item Development Specification provide an opportunity to specify the performance characteristics of each desired instructional feature.

Performance Parameters: Enter the instructional features desired; e.g.,

"The trainer shall monitor student performance, score student responses, provide augmented feedback messages for specific exercises, present specific malfunction exercises, freeze, control the selection of the next activity, store student responses for later retrieval and highlight certain cues."

Enter a list of the instructional features which are required on the trainer.

Background and Sources: This is a new requirement. See AFHRL-TP-84-49 paragraph 2.1.2.7 for information on the logistical support associated with instructional features.

Lessons Learned: Malfunction insertion and monitoring of student performance were evaluated for the F-16 Simulated Aircraft Maintenance Trainers (SAMTs). The results indicated that malfunction insertion was generally well liked, and student monitoring was disliked among the respondents. According to the results, "Instructors felt that malfunction isolation could be taught . . . effectively on SAMTs," and "the ability to show students the behavior of a malfunctioning system and to emphasize the results of student actions in a realistic context was noted as one of the best features of a trainer." The majority of responses to automatic student monitoring were negative. Most instructors did not use the feature at all, and this lack of utilization was attributed to various factors, including the fact that when monitoring was turned on, every action was monitored. The large amount of collected data was difficult to read and

interpret.[5] Note that these results cannot necessarily be generalized to other trainers or other situations.

In a generic specification, it is difficult to recommend what instructional features a typical trainer should have. Instructional features are often dependent on the specific training objectives. In addition, little information exists concerning the training effectiveness of specific instructional features as applied to maintenance training. Cost data regarding the effectiveness of instructional features are difficult to obtain since other variables influence costs more than instructional features do, and cost breakdowns are not always available. Thus, no recommendations about instructional features are included in this Handbook.

3.2.1.5.1 INITIALIZATION AND WARM-UP.

"a. Warm-Up. The maintenance trainer shall be "ready" for initialization in no longer than ___ minutes after power turn-on under the environmental conditions specified in subparagraph 3.2.5 of this specification."

"b. Initialization. Initialization shall include all the functions to be accomplished by the instructor to initialize, verify, and configure the maintenance trainer for training. Initialization shall include the following activities: ______________________________
______________________________."

"c. After warm-up, initialization shall take no longer than ___ minutes."

This paragraph contains three blanks to be completed. Each blank is discussed separately below.

Rationale and Guidance (Item a): The length of warm-up time can be critical. It influences the preparation activities of the instructor.

Performance Parameters (Item a): In determining maximum warm-up time consider the following factors:

- Environmental conditions (e.g., a cold environment will require a longer warm-up period).

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[5]Fitzpatrick, J. A. & Hritz, R. J. Acquiring better maintenance trainers: Lessons learned in the F-16 SAMT study. AFHRL-TP-83-44, AD-A137133. Lowry Air Force Base, CO: Training Systems Division, Air Force Human Resources Laboratory. January 1984.

- The time available between scheduled classes (e.g., if the trainer is going to be powered down between classes, then the length of time between classes influences the maximum duration of warm-up).

- The type of training equipment (e.g., microprocessors take less time to warm up than do larger main frames).

The specifications reviewed in the preparation of this document indicate that a reasonable time would be between 5 and 8 minutes. Guidance can also be obtained by reviewing subparagraph 3.2.1.1a of the ISD-Based Training Equipment Design Specification.

Background and Sources (Item a): This is a relatively new requirement, but this item has appeared in some previous training equipment specifications.

Lessons Learned: Generally, the larger the computer internal memory is, the longer it takes for the computer to conduct parity checks/self-diagnostics which contribute to the warm-up time.

"b. Initialization. Initialization shall include all the functions to be accomplished by the instructor to initialize, verify, and configure the maintenance trainer for training. Initialization shall include the following activities: ________________ ________________."

Rationale and Guidance (Item b): If possible, the activities required to initialize the trainer should be specified. Often this is left to the contractor or vendor to determine.

Performance Parameters (Item b): When specifying the *initialization activities*, the preparer and/or contractor or vendor should consider the following as potential initialization activities:

- Loading the necessary operational programs to present the student with the problem exercise of interest.

- Verifying that the operational programs specified above are loaded.

- Selecting a specific pre-programmed malfunction from a menu of possible malfunctions (typically using a keyboard).

- Setting specific system parameters (using a keyboard) to create a specific malfunction condition which is not pre-programmed.

- Activating interfaces between components (e.g., turn on printer, disk driver, etc.).

- Setting the controls which activate or deactivate selected instructional features (e.g., each problem can present a menu of possible instructional features).

- Loading slides.

When completing this subparagraph, review the suggested initialization activities specified in subparagraph 3.2.1.1b of the ISD-Based Training Equipment Design Specification.

If the contractor or vendor is to establish the initialization activities, then consider the following wording:

> "Initialization activities shall be determined by the contractor or vendor and shall not exceed the time limits specified herein."

Background and Source (Item b): This is a new requirement; however, it has appeared in many training equipment specifications.

Lessons Learned (Item b): When determining the activities associated with initialization, consideration should be given to the order of the activities. In the F-16 program the daily readiness disk is loaded, initialized, run, and then removed. The run (operational) program is then loaded, initialized, and run. It has been suggested that two separate operations are unnecessary. Both programs should be combined into one program. The operational (run) program should include the daily readiness check.

> "c. After warm-up, initialization shall take no longer than minutes."

Rationale and Guidance (Item c): The length of time required to perform the initialization activities influences the demands on the instructor. The information given here will provide guidance for the contractor or vendor.

Performance Parameters (Item c): In determining the length of time for initialization activities, consider the following factors:

- Time available between scheduled classes.

- Time available between practice exercises within a given class.

- The number and kind of initialization activities (e.g., if entries are made on a keyboard and menus are provided, then the length of time to perform the initialization will be minimal).

A review of previous training equipment specifications indicates a reasonable time period for initialization would be 5 to 8 minutes. Some specifications reviewed specified a maximum time for both warm-up and initialization together (e.g., 10 to 15 minutes). When selecting a time, review the recommendations in subparagraph 3.2.1.1c of the ISD-Based Training Equipment Design Specification.

Background and Sources (Item c): This is a new requirement.

Lessons Learned (Item c):

3.2.1.5.2 MALFUNCTION EXERCISE SELECTION.

"a. Simulated malfunctions specified in subparagraph 3.2.1.3 of this specification shall be selected and/or made operational in the following manner: ________________ ____."

"b. Once selected, the effects of a malfunction shall remain until: ________________________________ ____."

"c. The maintenance trainer shall be designed to permit the creation of the future malfunctions specified in subparagraph 3.2.1.3 of this specification."

This subparagraph contains three items. Two of the items contain blanks: items a and b. For clarity each item is discussed separately below.

Rationale and Guidance (Item a): If malfunctions are going to be simulated, then the instructor needs to be able to select the malfunction that is to be presented to the student at any given time during the training. Malfunctions can be selected in many ways.

- Each student exercise can be a specific malfunction (i.e., each exercise by itself can represent one and only one set of malfunction conditions and each can be on a separate file).

- Malfunction conditions to be inserted can be selected from a menu of possible malfunctions (if the malfunctions are pre-programmed).

- Malfunctions can be created/inserted by having the instructor enter (from keyboard or using a sonic/light pencil and CRT screen) the value of selected parameters (e.g., the precise value of a reading or a display which represents a malfunction condition).

- Malfunction conditions can be created by mechanical means (e.g., the instructor can set switches on the back panels of the trainer or replace an operational LRU with one that is defective).

If an advanced course is going to use the trainer, then consideration should be given to allowing the instructor to select multiple malfunctions from a menu of possible malfunctions. If this capability is desired, it should be specified in this subparagraph; e.g., "Multiple malfunctions shall be selectable." If multiple malfunctions are going to be selected, it would be useful for the preparer to specify how multiple malfunctions should be selected. For example, single malfunctions could be matched with other malfunctions before the student exercise is to begin. However, if typically certain malfunctions in the operational equipment are matched with another malfunction, then the multiple malfunction could be selected as a single exercise; i.e., automatically the trainer would present the combination of malfunctions once any of the single malfunctions is selected. If the preparer has a preference, this preference should be stated in the specification.

If how the malfunctions are going to be selected and/or created is known, then this information should be communicated to the contractor or vendor in this subparagraph.

Performance Parameters (Item a): Different malfunctions may be selected or created differently. For example, malfunctions dealing with faulty fuses could be selected and/or created by the instructor's pulling operative fuses and installing faulty fuses, while malfunctions associated with the leading edge flaps could be selected from a menu of pre-programmed malfunction conditions. Thus, it is necessary to specify how specific malfunctions are to be selected and/or created, if known. This information can be presented in table form.

MALFUNCTION	SELECTION/CREATION METHOD

The left column should contain all the malfunctions specified in subparagraph 3.2.1.3 of the Prime Item Development Specification, while the right column contains the specification of the selection/creation method.

To complete this item, review the suggestions offered by the ISD analyst (see subparagraph 5.2.2a of the ISD-Based Training Equipment Design Specification).

Background and Sources (Item a): This is a new requirement.

Lessons Learned (Item a): If the malfunctions are going to be selected by the use of switches (mechanically, rather than using software), then it is critical that the contractor or vendor make provisions for providing space for spare switches. These spare switches can be used for the addition of more malfunctions in the future. It may be difficult to estimate how many spare locations the malfunction panel should have. Perhaps it is best to express this requirement as a percent of the malfunction switches which are known to be required. For example, "The contractor or vendor shall provide a 50% growth capacity of the malfunction switch panel."

"b. Once selected, the effects of a malfunction shall remain until: ______________________________."

Rationale and Guidance (Item b): The contractor or vendor should be given guidance concerning the procedures for deleting a malfunction, if they are known.

Performance Parameters: Consider the following wording:

"Once selected, the effects of a malfunction shall remain until:

(1) The student correctly identifies the malfunction or takes the proper corrective action.

(2) The trainer "freezes" on a critical and/or fatal error committed by the student.

(3) The instructor purposely cancels or deletes the malfunction conditions via the keyboard (secure means)."

Of these three, caution should be exercised when specifying how the malfunction effect is cancelled when a freeze occurs. There are those situations in which it may be desired to keep the effect of the malfunction operational when the freeze occurs. It may be desired to have the instructor explain why the freeze occurs, to cancel the freeze (via the keyboard), and have the student continue on the identification of the malfunction; i.e., continue in the malfunction exercise.

See subparagraph 5.2.2b of the ISD-Based Training Equipment Design Specification for further information.

Background and Sources (Item b): This is a new requirement. See subparagraph 5.2.2b of the ISD-Based Training Equipment Design Specification.

Lessons Learned (Item b):

3.2.1.5.3 MONITORING STUDENT PERFORMANCE.

"The maintenance trainer shall perform the following student monitoring functions: ______________________ ____."

Rationale and Guidance: Frequently it is desired to have the trainer monitor, automatically, student performance on any given student exercise.

Monitoring student performance can be a complicated and expensive instructional feature. The trainer can be given several functions to perform:

- It can sense a student response (i.e., "know" that the student has made a response such as activated a control).

- It can record a student response (i.e., store the information that the student made a response). Not all sensed responses need to be recorded by the trainer; some responses which are sensed can be recorded by the instructor and not the trainer.

- It can score a student response (i.e., determine if the response made by the student was correct or incorrect). Not all recorded responses need to be scored by the trainer; in some cases the instructor can score a response recorded by the trainer.

- It can report a student response and/or a scored response (i.e., inform the instructor of the response that was made or the score after a series of responses). Not all recorded or scored responses need to be reported.

The functions the trainer performs influences the costs associated with the trainer; e.g., sensing responses may be less expensive than scoring or reporting responses.

The selection and specification of monitoring instructional features is further complicated by the fact that certain learning objectives may require only certain monitoring features; e.g., one learning objective may require only sensing responses whereas another may require scoring and reporting. Thus, monitoring instructional features are learning objective specific.

In addition, the controls which activate monitoring features can vary; e.g.,

- The control can be an on/off control (e.g., an on/off sensing control would allow all or none of the students responses to be sensed during a particular exercise).

- The control can be a variable input control (e.g., the instructor, before the exercise begins, can select what variable or responses are to be sensed, recorded, scored and/or reported for that particular problem).

Thus, specifying and selecting these monitoring controls can be complicated. However, Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedure for Design and Documentation offers a procedure for selecting and specifying these monitoring instructional features (see Step 7 of that Handbook). If an ISD analysis has been performed, then these instructional feature decisions will have been made and recorded in subparagraph 5.2.5b of the ISD-Based Training Equipment Design Specification. If it is desired to have the contractor or vendor make these determinations, then the contractor or vendor should be directed to take these decisions according to the procedures specified in that Handbook.

Performance Parameters: Enter the monitoring functions the proposed trainer shall perform. The following represent a list of possible monitoring features which can be specified:

- On-off/select sensing.

- On-off/select recording.

- On-off/select scoring.

- On-off/select reporting.

- On-off/select system status.

- Adjust criteria level control (only if the trainer is scoring responses). This capability or feature allows the instructor to change the criteria against which the student response is compared when scoring the student response.

The items selected should be learning objective specific; i.e., the above items should be listed for each learning objective where they are required (see subparagraph 5.2.5 of the ISD-Based Training Equipment Design Specification for the type of tables that might be necessary).

It should be evident that certain instructional features imply the need for other devices; e.g., if student responses are to be reported, then a reporting device is needed, such as a CRT screen located at the instructor station. These other devices are discussed in a separate subparagraph of the Prime Item Development Specification.

Background and Sources: This is a new requirement.

Lessons Learned: Although this is a new requirement, some logical issues need to be addressed.

- As the number of variables or responses to be sensed, recorded, scored, or reported increases, the more complex the trainer becomes (e.g., more storage capacity is required).

- An increase in complexity (or at least an increase in the number of variables to be sensed, recorded, etc.) usually means an increase in cost; e.g., a larger computer may be needed.

- As more computer time and space (core) are devoted to handling the monitoring features, less computer time and space are available for other functions (e.g., controlling the displays and controls).

- The largest number of instructional features is not always the best. Depending on the specific simulator, a number of functions may be available but not practical for the specific training purposes in question.

Thus, the preparer of the Prime Item Development Specification must carefully balance the utility of these instructional features with their cost.

Studies need to be performed before the exact training and cost effectiveness of such instructional features can be determined.

3.2.1.5.4 FREEZE CAPABILITY.

"a. The maintenance trainer shall freeze under the following conditions: ______________________________ ______________________________."

"b. When unfrozen (deactivated), the maintenance trainer shall: ______________________________ ______________________________."

"c. The freeze, when activated, shall cause all displays, controls, indicators, etc. to remain fixed in their position at the moment of the freeze."

There are two blanks to be completed. Each is discussed separately below:

Rationale and Guidance (Item a): Under certain learning conditions/situations a freeze control is usually needed. The decision to have a freeze control is made by analyzing the psychological behaviors to be learned by the student using the trainer. If, in acquiring a specific learning objective, the learner or student can make an error which in the real world will result in personnel injury and/or severe damage to the actual equipment, then a freeze control is indicated.

Performance Parameters (Item a): Enter the conditions or circumstances that would cause an automatic freeze of the trainer's controls and displays; e.g.,

"The maintenance trainer shall freeze under the following conditions:

(1) When the student performs an operation (manipulation of controls) which would result in personnel injury in either the job environment and/or the training environment.

(2) When the student performs an operation (manipulation of controls) which would result in damage to the actual equipment or the trainer in either the job environment and/or the training environment."

Often a third condition is specified:

(3) "When a procedural error has been made."

It should be pointed out that another option exists. The description above indicates that freeze is pre-programmed (occurs automatically). It is quite possible for the instructor to monitor student performance and freeze the trainer upon demand; i.e., the trainer is not programmed to freeze but the instructor activates a switch which causes all displays and controls to freeze. This option or alternative is less expensive (since the trainer doesn't have to monitor the student performance), but will require more effort from the instructor (since now the instructor would have to monitor the student's performance). The training and cost effectiveness of these two approaches have not yet been determined.

If it is desired to have both an automatic and manual freeze capability, this capability should be specified within this item; e.g.,

> "The trainer shall freeze automatically under the conditions specified above. It shall manually freeze upon demand of the instructor."

The preparer of this specification should see subparagraph 5.2.1a of the ISD-Based Training Equipment Design Specification for the results of the ISD analysis.

Background and Sources (Item a): This is a new requirement.

Lessons Learned (Item a): Studies need to be done to determine the training and cost effectiveness of both the automatic and the instructor demand freeze capability.

Currently the Prime Item Development Specification does not make provisions for two other possible requirements concerning the freeze capability. For example, it does not discuss the requirement for alerting the student that a freeze has occurred and does not discuss how the freeze is to work with other possible instructional features, such as the level of aiding or cue enhancement. Both of these types of requirements can be specified within item a of this subparagraph. For example, under item a the following may appear. (It is also possible to make this requirement item d within this subparagraph.)

> "The student shall be alerted that a freeze has occurred by: ____
> ____."

The preparer would complete the blank specifying how the freeze condition will be made known to the student. There are many possible ways the freeze can be made known to the student. A partial list of ways is suggested below:

- A loud tone could be started.
- A bright or flashing light could be activated.
- A slide could appear indicating the trainer is frozen.
- A message could be sent via the printer or the CRT if one is part of the Student Station, or a message could be sent to the printer or CRT at the Instructor Station.
- The trainer could simply refuse to accept additional student responses.

When selecting the method of alerting the student of the freeze, be sensitive to the possible embarrassing aspects to the student. If the preparer has a method in mind, it should be communicated to the contractor or vendor.

The second issue, the issue concerning the interaction effect between the freeze and the other instructional features, can also be handled within this item (or it can be designated as item d or e within this subparagraph). The following wording is suggested:

> "The freeze capability shall be operational in conjunction with the other instructional features specified herein. The freeze conditions shall be independently selectable."

Although the freeze conditions are independently selectable, it should be realized that they may work differently with other specified instructional features. For example, if a freeze condition is specified with a certain level of cueing, it is perhaps reasonable that a different learning environment will be created. For purpose of design, it is sufficient to say that each instructional feature will function independently, but that it will interact with the other instructional features. The given instructional features selected by the instructor at the beginning of each lesson will determine the possible interactions.

> "b. When unfrozan (deactivated), the maintenance trainer shall: ________________________________ ____."

Rationale and Guidance (Item b): If a freeze control is a requirement, then a requirement must be made for what happens after the freeze situation.

Performance Parameters (Item b): After the trainer's controls and displays have been frozen, the following options are available:

- The trainer can continue (as if the freeze had not occurred), provided the instructor or the trainer itself is given the opportunity to explain to the student why the freeze occurred; this would require the trainer to rectify the error(s) leading to the freeze.

- The exercise can be restarted from the beginning (after the reason for the freeze is presented to the student); this may require re-initialization.

- The trainer can automatically "back up" to the first error and force the student to continue from that point (after the reason for the freeze has been explained); this would require the trainer to rectify the committed errors or require the instructor or student to cancel the committed errors.

The selection of one of these approaches involves careful analysis of the behavior being learned on the trainer. A decision process has been provided in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedure for Design and Documentation (Step 7). The results of this decision are recorded in subparagraph 5.2.1d of the ISD-Based Training Equipment Design Specification.

Background and Sources (Item b): This is a new requirement.

Lessons Learned (Item b): Further study is required to determine the training and cost effectiveness of these techniques.

3.2.1.5.5 AUGMENTED FEEDBACK CAPABILITIES.

"The maintenance trainer shall be: ____________________
____."

Rationale and Guidance: There are two types of feedback that can be provided to the student using trainers.

- Feedback which the student receives directly from the simulated equipment (e.g., when a control is manipulated to a specific location, the indicator on the control or on a display associated with the control indicates whether or not the student performed correctly).

- Augmented feedback (i.e., feedback which is verbal or written in nature and communicates to the student the correctness or incorrectness of a response as well as a reason why the response may be correct or incorrect). Augmented feedback is not a substitute for the type of feedback discussed in item a above.

The first type of feedback is considered when determining the fidelity of the components to be represented on the maintenance trainer; i.e., the feedback characteristics of the simulated component specified in subparagraph 3.2.1.4.1 of the Prime Item Development Specification. This subparagraph is concerned with providing augmented feedback.

The need for augmented feedback is determined by analyzing the behaviors being taught on the trainer. The procedures for this analysis are specified in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation (Step 7).

When augmented feedback is required (determined by ISD analysis), then several issues need to be addressed:

- When should augmented feedback be given to the student--immediately after a given response is made or on a delayed feedback schedule?

- What content should be given in the feedback message?

Feedback schedule and content depend on the specific learning objective being attained (i.e., augmented feedback is learning objective specific).

There are several controls associated with augmented feedback:

- An on-off control, which turns on or off the feedback capability. (There are times during training when no augmented feedback should be given to the student; e.g., in the later stages of learning.)

- A select augmented feedback schedule control. (This control allows the instructor to set, for a given exercise, the feedback schedule [delayed vs. immediate].)

- A control or device which allows the instructor to adjust, change, or modify the feedback message given to the student.

These decisions are also made following the procedures specified in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation (Step 7).

Performance Parameters: Enter the desired augmented feedback capabilities and controls; see subparagraph 5.2.6 of the ISD-Based Training Equipment Design Specification. If possible, make sure the desired augmented feedback capabilities and controls are learning objective specific.

Also, if possible, specify the content of the augmented feedback message for each specified objective. This may require the identification of possible student errors.

For convenience, this information might be presented in table form.

LEARNING OBJECTIVES	FEEDBACK SCHEDULE	FEEDBACK MESSAGE	CONTROLS

Background and Sources: This is a new requirement.

Lessons Learned: Previously augmented feedback capabilities and controls were specified for the trainer as a whole. An attempt is being made in this document to specify the augmented feedback capabilities per objective.

3.2.1.5.6 NEXT ACTIVITY CONTROL FEATURES.

"The maintenance trainer shall control the next activity of the student in the following situations: ______ ____."

Rationale and Guidance: One of the aspects of the learning environment that the trainer can control is the next activity of the student after an objective is completed or a student error is made. The freeze control is a mechanism to select the next activity under certain situations. This subparagraph should be used to specify the other next activities to be controlled by the trainer.

If the next activity is going to be controlled by the maintenance trainer rather than the instructor, then the contractor or vendor needs to know:

- What the next activity is to be.
- If the next activity is to be pre-programmed.
- If the instructor can override the pre-programmed next activity (and select the next activity from a menu of possible next activities).
- If the instructor can alter the pre-programmed next activity (i.e., alter the branching that has been pre-programmed).

A procedure for making these decisions is specified in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation (Step 7).

Performance Parameters: For each objective (and/or student exercise) enter the next activity to be introduced to the student (if and only if the maintenance trainer is going to control the next activity). If the trainer has no control over the next activity, then nothing needs to be entered; i.e., this subparagraph can be omitted.

If the maintenance trainer is going to automatically present the next activity (a pre-programmed next activity), then specify if only one next activity is possible. If more than one next activity is possible, then specify all the possible next activities. If more than one next activity is possible specify the conditions which the trainer must examine to determine the most feasible next activity (i.e., specify the conditions which lead to a single next activity). If more than one next activity is possible, but it is desired not to have the trainer make the decision, then indicate that a menu will appear to allow the instructor to select the next activity.

If the next activity is going to be pre-programmed or if a menu is going to be generated, specify if it is desired to have the instructor change or modify the pre-programmed branching and/or add other next activities to the generated menu.

For convenience, this information may be presented in table form.

OBJECTIVE NUMBER	NEXT ACTIVITIES	PRE-PROGRAMMED		MENU
		NO CHANGE	FUTURE CHANGE	

If an ISD analysis has been performed, see subparagraph 5.2.7 of the ISD-Based Training Equipment Design Specification.

Background and Sources: This is a new requirement.

Lessons Learned: Often the next activity can be controlled by the simulator and the instructor, allowing for greater flexibility in the design of the maintenance course. Additional

research needs to be conducted to determine the training and cost effectiveness of next activity controls.

3.2.1.5.7 STIMULUS CONTROL FEATURES.

"a. The maintenance trainer shall present the stimuli for the specified learning objectives (and/or exercises) at the following rates: ____."

"b. The maintenance trainer shall present the following stimuli at the following signal-to-noise ratios: ____."

Rationale and Guidance: One of the aspects of the learning environment that needs to be controlled (either by the instructor or the maintenance trainer) is the presentation of the stimuli. Two aspects of stimuli presentation can be controlled: the rate of stimuli presentation and the ratio of signal to noise. The rate of presentation should be specified as the number of stimuli to be presented per minute. The ratio of signal to noise (the amount or strength of the stimuli to the amount of noise or interference) should be specified as a ratio (e.g., 10 to 1).

Notice that the rate and signal-to-noise ratio are learning objective specific; i.e., the rate and signal to noise ratio can be different for different learning objectives.

Performance Parameters:

"a. The maintenance trainer shall present the stimuli for the specified learning objectives (and/or exercises) at the following rates: ____."

Enter the rates for those objectives (and/or exercises) for which the trainer shall have control over the presentation rates. If the instructor is to control the rate of presentation, the item need not be completed. If the exact rate is not known, specify a range of rates. Also indicate if it is desired to give the instructor the capability to change or modify the rate in the future. For convenience, this information can be presented in table form.

A procedure for making these decisions is specified in Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation (Step 7).

Performance Parameters: For each objective (and/or student exercise) enter the next activity to be introduced to the student (if and only if the maintenance trainer is going to control the next activity). If the trainer has no control over the next activity, then nothing needs to be entered; i.e., this subparagraph can be omitted.

If the maintenance trainer is going to automatically present the next activity (a pre-programmed next activity), then specify if only one next activity is possible. If more than one next activity is possible, then specify all the possible next activities. If more than one next activity is possible specify the conditions which the trainer must examine to determine the most feasible next activity (i.e., specify the conditions which lead to a single next activity). If more than one next activity is possible, but it is desired not to have the trainer make the decision, then indicate that a menu will appear to allow the instructor to select the next activity.

If the next activity is going to be pre-programmed or if a menu is going to be generated, specify if it is desired to have the instructor change or modify the pre-programmed branching and/or add other next activities to the generated menu.

For convenience, this information may be presented in table form.

OBJECTIVE NUMBER	NEXT ACTIVITIES	PRE-PROGRAMMED		MENU
		NO CHANGE	FUTURE CHANGE	

If an ISD analysis has been performed, see subparagraph 5.2.7 of the ISD-Based Training Equipment Design Specification.

Background and Sources: This is a new requirement.

Lessons Learned: Often the next activity can be controlled by the simulator and the instructor, allowing for greater flexibility in the design of the maintenance course. Additional

research needs to be conducted to determine the training and cost effectiveness of next activity controls.

3.2.1.5.7 STIMULUS CONTROL FEATURES.

"a. The maintenance trainer shall present the stimuli for the specified learning objectives (and/or exercises) at the following rates: ____."

"b. The maintenance trainer shall present the following stimuli at the following signal-to-noise ratios: ____."

Rationale and Guidance: One of the aspects of the learning environment that needs to be controlled (either by the instructor or the maintenance trainer) is the presentation of the stimuli. Two aspects of stimuli presentation can be controlled: the rate of stimuli presentation and the ratio of signal to noise. The rate of presentation should be specified as the number of stimuli to be presented per minute. The ratio of signal to noise (the amount or strength of the stimuli to the amount of noise or interference) should be specified as a ratio (e.g., 10 to 1).

Notice that the rate and signal-to-noise ratio are learning objective specific; i.e., the rate and signal to noise ratio can be different for different learning objectives.

Performance Parameters:

"a. The maintenance trainer shall present the stimuli for the specified learning objectives (and/or exercises) at the following rates: ____."

Enter the rates for those objectives (and/or exercises) for which the trainer shall have control over the presentation rates. If the instructor is to control the rate of presentation, the item need not be completed. If the exact rate is not known, specify a range of rates. Also indicate if it is desired to give the instructor the capability to change or modify the rate in the future. For convenience, this information can be presented in table form.

OBJECTIVE NUMBER	PRE PROGRAMMED		CAPBILITY TO ALTER OR SELECT RATIO
	FIXED RATIO	VARIABLE RANGE	

The preparer should examine subparagraph 5.2.8a of the ISD-Based Training Equipment Design Specification if an ISD analysis has been performed.

"b. The maintenance trainer shall present the following stimuli at the following signal-to-noise ratios: ______________________________ ______________________________."

Enter the ratio of signal to noise for each objective (and/or exercise) where the maintenance trainer shall have control over the signal-to-noise ratio. If a specific ratio cannot be identified, then enter a range of ratios or enter a qualitative statement (e.g., high signal to low noise). Also, specify if the ratios are to be pre-programmed or input by the instructor before the exercise begins. In addition, indicate if it is desired to have the instructor alter or modify any pre-programmed ratios. For convenience this information can be presented in table form.

OBJECTIVE NUMBER	PRE-PROGRAMMED		CAPABILITY TO ALTER OR SELECT RATIO
	FIXED RATE	VARIABLE RANGE	

For further guidance see subparagraph 5.2.8b of the ISD-Based Training Equipment Design Specification.

Background and Sources: This is a new requirement.

Lessons Learned: Additional research needs to be conducted to determine the training and cost effectiveness of stimulus control instructional features.

3.2.1.5.8 CUE ENHANCEMENT CONTROL FEATURES.

"The following cues (either stimuli or responses) shall be enhanced during the following learning objectives (and/or exercises): ______________________________ ______________________________."

Rationale and Guidance: Often it is desirable in the training situation to highlight cues to performance; e.g., when performing or learning a sequence, it may be desirable early in training to highlight the stimulus associated with each sequence -- this will usually decrease the amount of time it takes for the student to acquire satisfactory performance of the sequence.

Notice that the cues to be enhanced will be different for different objectives and/or exercises; i.e., cues are learning objective specific. Thus, in this specification, you must identify which objectives require cue enhancement, as well as identify what cues for that objective must be enhanced.

The decision to enhance certain cues (as well as the decision to have the trainer control these enhancements) is made by following the procedures in Maintenance Training Simulator Design and Acquisition - Handbook of ISD Procedures for Design and Documentation (Step 7).

Performance Parameters: Enter the learning objectives that require cue enhancement; also specify the cue(s) to be enhanced. Include only those learning objectives (and/or exercises) where the cue enhancement strategy is going to be controlled by the maintenance trainer. If control is left to the instructor, the learning objective (and/or exercise) need not be specified in this subparagraph.

Also specify if the cue enhancement strategy is going to be pre-programmed or variable input. (Variable input allows the instructor to specify before each exercise the cues to be enhanced.) For convenience, this information can be presented in table form.

OBJECTIVE NUMBER	CUE TO ENHANCE	PRE-PROGRAMMED	VARIABLE

If possible, specify the cue enhancement strategy; e.g., increase the intensity of the cue or decrease the intensity of surrounding cues.

When completing this subparagraph, see subparagraph 5.2.9 of the ISD-Based Training Equipment Design Specification for the results of the ISD analysis.

Background and Sources: This is a new requirement.

Lessons Learned: Additional research needs to be conducted to determine the training effectiveness and cost effectiveness of cue enhancement controls and capabilities.

3.2.1.5.9 SIGN-IN CAPABILITY.

"a. During sign-in the maintenance trainer shall request the following information: ____."

"b. Sign-in shall be the responsibility of: ____."

Rationale and Guidance: If the maintenance trainer is going to record, score, or report student responses (and if responses are going to be stored for future reference or retrieval), then a sign-in capability is required.

When specifying a sign-in capability, two issues need to be addressed.

- What information should be requested by the trainer?
- Who performs the sign-in activity (student, instructor, or both)?

Notice that a sign-in capability implies the need for a sign-in device (e.g., terminal or keyboard).

Performance Parameters:

"a. During sign-in the maintenance trainer shall request the following information: ____."

Enter the information to be requested by the trainer during the sign-in activity. Consider the following information:

- Student's name (if a team, the name of team members).

- Student's I.D.

- Learning objective and/or exercise number.

- Attempt number (number of practices allowed).

- Configuration data (e.g., level of cueing).

Also specify how information is to be requested (e.g, displayed on the CRT).

"b. Sign-in shall be the responsibility of: ________ ____."

Enter who has the responsibility to enter the sign-in information. This can be the responsibility of the instructor, student, or both. If both the instructor and student are to be responsible, specify who provides what information.

See Paragraph 5.2.3b of the ISD-Based Training Equipment Design Specification for guidance on specific input for this application.

Background and Sources: This is a new requirement.

Lessons Learned: Experience with the F-16 SAMTs has shown that it is not desirable for the student to sign in at the CRT/ keyboard. This has been viewed as an unnecessary student action and requires additional training time for each student (in the use of the keyboard). Since the trainer's intent is to train the student in maintaining the weapon system (and not to work with the control keyboard of the trainer), it is felt that minimum interface with the control keyboard would be desirable. The student does not have to sign in when operating/maintaining the weapon system, and thus, should not have to do so when being trained. Thus, it is recommended that the instructors perform the sign-in function.

3.2.1.6 UTILIZATION.

"The maintenance trainer shall provide efficient training in the following situations: ______________ ____."

Rationale and Guidance: This subparagraph provides an opportunity to specify the planned instructor-to-student ratio, as well as general information concerning how the trainer is to be used.

<u>Performance Parameters</u>: Supply the following information:

- "A classroom demonstration situation having an instructor-to-student ratio of ____________________."

- "A student practice situation involving no more than ____ students with (or without) instructor assistance."

Notice that a trainer is normally used in two ways: as a demonstration medium and as a practice medium for the student. It is important to specify the ratios involved in each situation. Typically, in the demonstration situation, the ratio of instructors-to-students will be no greater than 1 to 10. This ratio would depend upon:

- The typical class size.

- The physical size of the trainer. (A smaller physical size usually means that fewer students can actually observe the demonstration).

In the practice situation a typical ratio is one instructor to two students (if teams are required). Often one student can observe while the other student practices (if a team is not required). When specifying the practice situation, be sure to indicate if the practice is to occur with or without instructor assistance. There is a trend to design trainers such that the practice session can be a self-learning experience (requiring only initialization by the instructor). When completing this subparagraph, the preparer should review subparagraphs 3.3.2<u>a</u> and <u>b</u> of the ISD-Based Training Equipment Design Specification, which documents the results of the ISD analysis.

<u>Background and Sources</u>: This is a further clarification of subparagraph 20.3.2.1b of MIL-STD-490 (page 34).

<u>Lessons Learned:</u> Many recently built maintenance trainers are designed such that instruction can be self-paced. There are psychological benefits to this feature as well as time/cost benefits. Research has shown that students tend to enjoy the learning/training process more when they go at their own pace, and when they are the only ones who see their mistakes.[6]

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[6]Carroll, R. J., Thocher, L. T., Roth, J. T., and Massey, R. H. <u>Maintenance training simulators: Their use, cost, and perceived effectiveness</u>. AFHRL-TR-84-53. Lowry Air Force Base, Colorado: Training Systems Division. 1985.

Students who learn at an above average rate of speed can proceed at a faster rate through the instructional sequence, thereby shortening the course and saving money. Of course, the material to be trained and other constraints will determine the appropriateness of a self-paced approach.

3.2.1.7 USEFUL LIFE/OPERATIONAL SERVICE LIFE.

"a. The maintenance trainer shall have a useful life of not less than _____ years under any of the operating and non-operating environments specified herein."

"b. Other than for periodic and scheduled preventative maintenance, the maintenance trainer shall operate for ____ hours/day, ____ days/week, and ____ weeks/year."

"c. The maintenance trainer shall have an operational service life of not less than ____ hours. Operational service life is defined as the total operating time between the start of the operation and wear-out, where wear-out is defined as the point when overhaul or repair cost exceeds one-half of the replacement cost of the maintenance trainer."

Rationale and Guidance: The information requested in this subparagraph of the Prime Item Development Specification provides the contractor or vendor with guidance in selecting the materials to use when designing and fabricating the maintenance trainer, as well as providing information to the preparer for computing spares and life cycle costs. There are three blanks to be completed. Each is discussed below.

Performance Parameters:

"a. The maintenance trainer shall have a useful life of not less than _____ years under any of the operating and non-operating environments specified herein."

Enter expected useful life in years. Typically trainers are expected to have a useful life of at least 10 to 15 years. However, this depends on the expected life of the weapon system being simulated.

"b. Other than for periodic and scheduled preventative maintenance, the maintenance trainer shall operate for _____ hours/day, _____ days/week, and _____ weeks/year."

Enter the expected operating hours/day, days/week, and weeks/year in the spaces provided. When completing these blanks, consider the following factors:

- Length of course in which trainer will be used (in hours).
- Length of time trainer will be used for demonstration and practice (percentage of total course length).
- Expected number of courses offered per year.
- Number of students per course.
- Hours/day = (length of course in hours/day) X (average percentage of hours/day used for demonstration + average percentage of hours per day for practice).

"c. The maintenance trainer shall have an operational service life of not less than ____ hours. Operational service life is defined as the total operating time between the start of the operation and wear-out, where wear-out is defined as the point when overhaul or repair cost exceeds one-half of the replacement cost of the maintenance trainer."

Enter minimum operational service life in hours. Operational service life can be computed by the following formula:

Operational service life = (life expectancy in years) X (hours/day) X (days/week) X (weeks/year).

Notice that this computational procedure makes wear-out equal to life expectancy.

<u>Background and Sources</u>: This is a further clarification of subparagraph 20.3.2.1b of MIL-STD-490 (page 34). (NOTE: No military standard or specification was referenced in developing the formulas that were specified in the above paragraph.)

<u>Lessons Learned</u>:

3.2.2 PHYSICAL CHARACTERISTICS.

3.2.2.1 WEIGHT LIMITS.

"a. The total weight of the maintenance trainer, in the operating configuration(s), shall not exceed ____ kilograms."

"b. Maximum floor loading shall not exceed _____ kilograms per square meter."

This subparagraph contains two items. Each item requires the insertion of a weight or a force. Notice that the units are expressed in metric units. There is a move toward specifying units using the metric system. MIL-M-38784A (which is for technical manuals) in paragraph 3.3.1e states the following, "When the metric system is used on equipment, conversion to U.S. standards shall follow in parentheses." Thus, the preparer should consider placing the U.S. standard equivalent in parentheses.

Rationale and Guidance: The information supplied in this subparagraph is to provide guidance to the contractor or vendor when designing and fabricating the proposed maintenance trainer.

There are two approaches to follow when providing these requirements:

- Specify a maximum based upon MIL-T-81821 or

- Specify the characteristics of the facility (if known).

Performance Parameters: Enter desired maximum weight in kilograms; kilograms = pounds/2.205. NOTE: MIL-T-81821 (paragraph 3.2.2.2) specifies the following:

"... weight shall be held to a minimum consistent with cost, available space, and training effectiveness. ...The weight of each trainer panel in the transporting and operating configuration shall not exceed three thousand (3,000) pounds. ... weight in excess of these limitations will be acceptable only when specifically authorized by the Procuring Activity ...."

Floor loading can be computed using the following formula (see MIL-T-81821, paragraph 3.7.2.1):

$$F = \frac{W}{C \times N}$$

where

F = Concentrated single-point floor loading in psi.
W = Total weight of trainer panel in pounds.
C = Caster or jack pad footprint in square inches of floor area covered.
N = Number of casters or jack pads on trainer panel.

To determine floor loading without casters, substitute the square inches of trainer support structure in contact with the floor for C X N in the above formula. To convert psi to kilograms per meter, multiply psi times 1.4888. NOTE: Paragraph 3.7.2.1 of MIL-T-81821 specifies a minimum of four casters per trainer panel; the same paragraph specifies:

> "Each caster shall not impose a concentrated single-point floor loading greater than 100 pounds per square inch."

The wording offered above can be altered to reflect the number of casters; e.g., "Maximum floor loading shall not exceed _____ kilograms per square meter, when equipped with _____ casters."

If the maximums offered in MIL-T-81821 are used, the preparer should be sure these maximums are consistent with the facility that will house the trainer. This may require the engineer to call the facility manager.

Background and Sources: Requirements specified in MIL-T-81821 and MIL-STD-490 (paragraph 20.3.2.2a). Also see AFHRL-TP-84-49, paragraph 2.2.2.3 on the logistics associated with overly heavy trainers.

Lessons Learned: The preparer should allow for the possibility that the trainer will be moved across a false floor; e.g., a computer room floor.

3.2.2.2 PHYSICAL DIMENSIONS.

> "The maintenance trainer shall have the physical dimensions compatible with the following operating and transporting characteristics:
>
> a. Operating Configuration
>
> (1) Operating in a room ____ meters (length), by ____ meters (width), by ____ meters (height).
>
> (2) Passage through doorways with maximum dimensions of ____ meters (width) by ____ meters (height).

(3) Passage through hallways with maximum dimensions of ______ meters (width), by _____ meters (height), and a minimum of ______ meters (length) between corners or turns.

b. Transporting/Shipping Configuration

The maximum transporting dimension of the trainer shall be ______ meters (length), by ______ meters (width), by ______ meters (height)."

Rationale and Guidance: This subparagraph contains two items. It should be noted that both items required dimensions to be presented in metric units. The preparer may elect to place the U.S. standard units in parentheses.

There are two approaches in providing the information requested: (1) to specify the dimensions of the facility that will house the proposed trainer, or (2) to specify maximum dimensions.

The approach adopted here is to specify the dimensions of the facility (provided the characteristics of the facility are known). For convenience, maximums are also provided below.

Performance Parameters: Enter physical dimensions of classroom, doorways, and hallways (if known). To convert feet to meters, multiply feet times 0.3048.

Also specify the shipping/transporting or storage dimensions (if known). For convenience, maximums are also provided below.

The preparer should review subparagraph 6.3 of the ISD-Based Training Equipment Design Specification.

Background and Sources: MIL-T-81821, paragraph 3.2.2.2 specifies:

"... dimensions ... shall be held to a minimum consistent with cost, available space, and training effectiveness. The maximum transporting dimensions of any trainer panel shall be seventy-two (72) inches in height, sixty (60) inches in width, and one hundred forty-four (144) inches in length."

If the operating facility is not known, the above paragraph can be used instead of the wording offered in the Prime Item Development Specification. These maximum requirements can be used for both shipping and operating configurations.

These suggested requirements are a further clarification of paragraph 20.3.2.2b of MIL-STD-490. Also see AFHRL-TP-84-49, paragraphs 2.2.2.2 and 2.2.2.6 on logistics factors associated with simulator size.

Lessons Learned: It may be advisable to include the following wording:

> "Dimensions in excess of these limitations will be acceptable only when specifically authorized by the procuring activity. If the size of the end item components used in the trainer preclude compliance with the limitations specified herein, and deviations are not acceptable to the procuring activity, the size of the components may be reduced by removing those sections or portions of the trainer which contribute the least significant training value."

See paragraphs 3.2.2.2 and 3.2.2.2.1 of MIL-T-81821 for further information.

3.2.2.3 MOMENTS.

"a. In the operational configuration the trainer and/or any of its separate components shall not be capable of being overturned by a ______-kilogram horizontal force applied in any direction at the top of the trainer or any of its separate components."

"b. In the shipping configuration the center of gravity of the trainer and/or any of its separate components shall not be more than ______ percent of its height above the bottom, more than _____ percent of its length longitudinal from the center, or more than ____ percent of its width fore or aft from the center."

Rationale and Guidance: This item contains two items. Notice the first item requires that a force be inserted in metric units. The preparer should consider placing U.S. standard units in parentheses.

This subparagraph is usually included for safety reasons. It is not desirable to have the trainer easily tipped over by the student or by those personnel responsible for shipping or maintenance.

Performance Parameters: Enter information requested. MIL-T-81821 (paragraph 3.2.2.2.2) recommends the following:

a. First blank - seventy-five (75) pound horizontal force (to convert pounds to kilograms divide pounds by 2.205).

b. All remaining blanks - twenty-five (25) percent.

Background and Sources: Requirement originates from MIL-STD-490 (paragraphs 20.3.2.2d and e) and is further clarified in paragraph 3.2.2.2.2 of MIL-T-81821.

Lessons Learned:

3.2.2.4 WORK AND STORAGE AREAS.

"The maintenance trainer shall: ______________________ ____."

Rationale and Guidance: Trainers should provide for a work area, particularly if T.O.s need to be used during the student practice sessions. This work area should be large enough to hold the T.O. or other job material comfortably.

In addition, it is often prudent to make storage provisions in both the student station and the instructor station for storage of technical materials, T.O.s, student manuals, instructor manuals, spare parts, and loose equipment.

Performance Parameters: Consider the following wording:

> "...have work areas to be used by the student which extend across the full length of trainer and have a width which allows the largest T.O. or other job material to remain in the work area without any of its edges extending over the edge of the work area. All work areas shall be 36 inches above the floor level."

> "All trainer panels and the instructor station shall have a sufficient amount of enclosed space for storage of ____ ____ (specify material to be stored; e.g., T.O.s, student manuals, loose equipment, etc.). Access to these storage areas shall not require the use of tools."

If the trainer uses high voltages, then a statement should be made in this subparagraph or in the SAFETY paragraph concerning the materials to be used for the work area. Consider the following wording (see MIL-T-82821, paragraph 3.2.2.3):

"To reduce the possibility of personnel injury due to contact with high voltages inherent in certain electronic equipment, the trainer bench top, including any folding extensions, shall be surfaced with a nonconductive material cemented to the bench top or secured with non-conductive fasteners. The material selected shall be durable, wear resistant, impervious to moisture, and shall not support combustion. The edges of the bench top shall be trimmed with a nonmetallic, nonconductive material."

Background and Sources: This is a further clarification of subparagraph 20.3.2.2 of MIL-STD-490 (page 34).

Lessons Learned:

3.2.2.5 ATTACHMENT OF COMPONENTS.

"Each major component and subassembly shall: ____________
____."

Rationale and Guidance: This subparagraph of the Prime Item Development Specification should be completed only if it is envisioned that attachment of components or subassemblies will be required in the design and fabrication of the maintenance trainer, such as clocks, cameras, or complete units or panels (e.g., multi-panel units).

Performance Parameters: Consider the following wording from MIL-T-81821 (paragraph 3.2.2.4):

"Each major component and subassembly shall be attached in a manner that will permit easy and ready access to its interior parts, terminals, and wiring for complete circuit checking and for removal of component parts. It shall not be necessary to displace or remove wires, cables, or subassemblies in order to gain access to mounting screws, terminals, soldered connections, etc. Components which are subject to replacement or servicing shall not be permanently secured by rivets, welding, or other means which prohibit ready removal. Clocks, cameras, and other high pilferage items shall be secured in a manner that will discourage ready removal. Provisions for sectional teardown and breakaway of major components shall be incorporated in the trainer panels for maintenance and transportation considerations. Means of attachment of components shall consider safety engineering factors."

Background and Sources: See paragraph above, plus MIL-STD-490 (paragraph 20.3.2.2, page 34).

Lessons Learned:

3.2.2.6 OTHER DIMENSIONS AND TOLERANCES.

"____
____."

Rationale and Guidance: This subparagraph provides an opportunity for the preparer to specify any other dimensions and tolerances not considered in subparagraphs 3.2.2.1, 3.2.2.2, 3.2.2.3, 3.2.2.4, or 3.2.2.5 of the Prime Item Development Specification.

Performance Parameters: Enter any other specific information concerning dimensions and tolerances of components or subassemblies; e.g., if trainer panel plumbing (fluid lines) are to be part of the maintenance trainer, see subparagraph 3.2.2.5 of MIL-T-81821 for guidance on dimensions and tolerances. In fact, that subparagraph itself may be inserted into the Prime Item Development Specification.

If it is impossible to provide more specific information concerning and other dimensions and tolerances, the following general wording might be inserted:

> "Dimensions and tolerances not specified shall be as close as is consistent with the best workmanship practices. Where dimensions and tolerances may affect interchangeability, operation, or performances of the trainers, they shall be held or limited accordingly."

The above wording originates from MIL-T-81821, subparagraph 3.2.2.3.

Background and Sources: The requirement originates from MIL-T-81821 and is a further clarification of paragraph 20.3.2.2 of MIL-STD-490.

Lessons Learned:

3.2.2.7 OTHER PHYSICAL PROPERTIES.

> "Each component shall be designed and constructed such that parts will not work loose in service or transportation. They shall be built to withstand strains, jars, vibrations and other conditions incident to shipping, storage, installation, and service."

3.2.2.8 SECURITY PROVISIONS.

"The following security provisions shall be made: ______ ______."

Rationale and Guidance: This subparagraph is included as a subparagraph of "PHYSICAL CHARACTERISTICS, since most security provisions will involve physical controls. As an alternative, the information in this subparagraph can be placed in a subparagraph under "PERFORMANCE."

The intent of this subparagraph is to provide an opportunity to specify any security requirements on any component or subcomponent of the maintenance trainer, as well as specify any security requirements on the simulated mathematical model or on the data used by the mathematical model that is to be stored on the maintenance trainer's storage devices or on the memory of the microprocessor.

Performance Parameters: Enter any component, subcomponent, part, LRU, or display and control that must be protected. For convenience this information can be presented in table form.

COMPONENT/SUBCOMPONENT	SECURITY CLEARANCE	METHOD OF PROTECTION

The first two columns are straightforward; in the last column, if possible, specify a reasonable method of protection.

For data and/or the mathematical model consideration should be given to the following:

- Data item by security clearance specification shall be as follows; e.g.,

DATA	SECURITY CLEARANCE

- "There shall be an efficient means to erase security data from the computer memory and temporary mass storage after execution of the mathematical model; such an erase shall be an automatic function. All security data shall be recreated automatically when student exercise requiring such data is again employed."

- "Permanent mass storage of security data shall be guaranteed against accidental exposure by physical means (control of disk or diskette) and by software means (e.g., requirement of passwords for retrieval of sensitive data)."

Background and Sources: This is a new requirement and represents a further clarification of subparagraph 20.3.2.2f of MIL-STD-490.

Lessons Learned: Attitudes towards data security and protection are varied. Some maintenance training simulator operators find the data protection systems easy enough to be practical, yet reasonably self-protective. Conversely, some operators feel that procedures for accessing data are made difficult by the need to sign on, belong to an authorized group, and have a password. Clearly, security provisions must be carefully designed to be user-friendly, and should not be more strict and time-consuming than actual security needs indicate.

In a recent survey sample on one maintenance training simulator, the instructor mode password could be changed, but the master password could not. In cases where security of data is a priority, such details should be carefully specified.

3.2.2.9 HEALTH AND SAFETY.

"All health and safety considerations are specified in subparagraph 3.3.6 of this specification."

3.2.3 RELIABILITY.

"a. All practical methods shall be employed that will ensure quality and reliability consistent with the state of technology."

"b. Reliability shall be integrated with maintainability efforts in order to achieve the availability specified in subparagraph 3.2.4.1, herein."

"c. Reliability shall be predicted during design, measured during testing, assured in production, and maintained in continued use."

"d. The maintenance trainer reliability requirements shall be as follows: ______________________________ ____."

This subparagraph contains four items. Only one of the items, item d, requires input from the preparer. Items a through c, inclusively, establish general reliability requirements. Item a states that the state-of-the-art technology should be employed to ensure the desired reliability. Item b specifies that the reliability of the trainer should be tied to the availability requirements of the trainer. Item c prescribes how the reliability program should operate during the design, development, and testing phases. Below is a discussion concerning item d.

Rationale and Guidance (Item d): The reliability of the trainer impacts upon the operational costs associated with the trainer.

Of critical importance is the decision to provide reliability estimates for the trainer as whole as well as reliability estimates for the major components comprising the trainer. A review of training equipment specifications indicates that the trend in the past has been to establish reliability estimates (and/or requirements) for the trainer as a whole, and not to specify the Mean Time Between Failures (MTBF) for the major components associated with the trainer. If this approach is adopted in this application, it must be made clear that the specified MTBF is for the whole trainer and that all equipment associated with the trainer (including the microprocessor and any and all computer peripheral equipment) shall be considered.

This subparagraph should be prepared with the assistance of the Reliability Monitor (if one has been assigned). Furthermore, before preparing this subparagraph, the following documents should be carefully read and consulted:

MIL-STD-781C	MIL-STD-756A
MIL-STD-785A	MIL-STD-757
MIL-STD-721A	

Although superseded by the documents specified above, the following documents may also be useful:

MIL-STD-781A	MIL-STD-778
MIL-STD-781B	MIL-STD-447

These documents should be carefully read so that:

- The definitions of failures are clearly understood (see MIL-STD-781C, paragraphs 3.1.3, 3.1.4, and 3.1.5, pages 3 and 4).

- The reliability program is clearly understood (MIL-STD-785A).

- The definitions of MTBF are clearly understood (see paragraph 3.1.6 of MIL-STD-781C page 4).

- The definition of reliability is clearly understood (see MIL-STD-751B).

- The concept of reliability prediction is clearly understood (see MIL-STD-756A).

- The concept of reliability evaluation from demonstration data is clearly understood.

Performance Parameters (Item d): Enter Mean Time Between Failures (MTBF) in hours.

Consider the following:

> "The maintenance trainer shall have a Mean Time Between Failures (MTBF) of ___ hours, where MTBF is defined in accordance with subparagraph 3.1.6.5 of MIL-STD-781C and a failure is defined in accordance with subparagraphs 3.1.3, 3.1.4, 3.1.4.1, 3.1.4.2, and 3.1.4.3 of MIL-STD-781C. The MTBF shall include all equipment associated with the trainer including the processor and all computer peripheral equipment.
>
> The MTBF value shall be consistent with established preferred parts acknowledged with lowest failure rate values as supported by the latest technology.
>
> The contractor or vendor shall not be responsible for failure of unmodified Government Furnished Equipment (GFE) unless the failure is a result of the contractor's trainer design, which is not within the design limits of equipment operation."

The MTBF entered should be calculated following the procedures specified in MIL-STD-756A.

If possible, it would be helpful to specify in the specification the following:

- Desired consumer's risk (B)
- Desired producer's risk (α)
- Desired discrimination ratio (d)

These can be incorporated into the specification in the following manner:

> "The reliability program shall conform to the following parameters:
>
> a. Consumer's risk (B) of ___________.
> b. Producer's risk (α) of ___________.
> c. Discrimination ratio (d) of _______.
>
> Where each is defined in accordance with paragraphs 3.1.2.1, 3.1.2.2, and 3.1.2.3, respectively of *MIL-STD-781C*."

<u>Background and Sources</u> (Item <u>d</u>): Sources are identified in the discussion above. Also see AFHRL-TP-84-49, paragraph 2.5.2.4.

<u>Lessons Learned</u> (Item <u>d</u>): Trainer performance, in terms of reliability, is impacted by many factors. Examples include the basic design, material selection, production processing, installed environment, component interface, and maintenance. All modes of failure must be anticipated and analyzed. If possible, when preparing the content and text for this subparagraph, the distribution of accidents, incidents, or types of failures of previous maintenance trainers should be examined.

3.2.4 MAINTAINABILITY.

"a. The contractor or vendor shall not be responsible for maintainability requirements of actual support equipment, tools, or any other Government Furnished Equipment (GFE) as specified in this specification."

"b. Maintainability planning and implementation of such planning for new hardware shall include, but not be limited to, necessary maintainability analysis during design, measurements during testing programs, and necessary redesign anytime acceptable levels of availability cannot be attained."

"c. The maintenance trainer maintainability requirements shall be as follows: ______________________________ ______________________________."

This subparagraph contains three items, only one of which contains a blank (item c). Item a specifies that the contractor or vendor shall not be responsible for maintainability requirements on Government Furnished Equipment or property; i.e., the requirements specified in the specification shall not apply to Government furnished property or equipment. Although this is the usual case, the preparer may find it convenient to alter item a by adding a statement which clearly indicates that any equipment loaned to the contractor or vendor by the Government shall be the responsibility of the contractor or vendor to maintain. In addition, the preparer may want to add a statement which states that all equipment loaned or furnished to the contractor or vendor must be returned to the Government in operating condition. Item b specifies the requirements of the maintainability program; i.e, when measurements shall be used, etc. Item c is discussed below:

"c. The maintenance trainer maintainability requirements shall be as follows: ______________________________ ______________________________."

Rationale and Guidance (Item c): The maintainability of the trainer impacts the operational costs associated with the trainer.

This subparagraph should be completed with the assistance of the Maintainability Monitor (if one has been assigned).

When preparing the text for this subparagraph, the following documents should be reviewed:

MIL-STD-470
MIL-STD 471A

Performance Parameters (Item c): Maintenance tasks and time requirements are specified in MIL-STD-470 and 471A.

Typically the following information should be supplied:

a. "The maintenance trainer shall yield accumulated maintenance manhours of not more than ____ percent of accumulated operating time; where manhours are defined as a measure of the work required (i.e., the summation of the hours each person is required to participate in the work or to be on hand to participate; including scheduled and unscheduled

maintenance, but excluding supply and administrative tasks on the removable assemblies performed when on or off the maintenance trainer) and operating time is defined as that time (excluding downtime) during which an item is assigned to a specific organization for the purpose of performing the organizational mission."

b. "The maintenance trainer shall have a critical on-line corrective maintenance downtime no greater than ______ minutes and an on-line maximum corrective maintenance time not greater than ____ minutes" (see MIL-STD-471A; a typical value is usually specified in 90th percentile).

c. "The mean time to repair (MTTR) shall be ____ hours. MTTR shall be based on the sum of the corrective maintenance downtime for a given time divided by the sum of all corrected maintenance actions for that same period, excluding administrative and supply tasks."

This subparagraph should also include other maintenance considerations; e.g., the following items, if appropriate, should be specified as requirements:

- Permit maintenance with general maintenance tools normally available commercially.
- Permit adjustments, servicing, replacement of parts and/or components with minimum disturbance to other equipment parts.
- The trainers shall be designed to keep the maintenance requirements to a minimum, both in level of skill and number of personnel required to maintain the trainer.
- Equipment shall be designed for rapid and easy removal, replacement or repair of malfunctioning items by one individual.
- Access shall be determined by the frequency of maintenance action. Items that require frequent maintenance shall be the most accessible.
- Plug-in components shall be used where feasible.
- Parts that are affixed to the basic end items shall have adapters, leads, and fittings, and shall be permanently identified with part numbers of both the part and the item with which used.

- Electrical connectors shall be positively keyed and labeled to prevent incorrect connection with other accessible connectors.

- Electrical connectors shall be arranged such that the keying devices are oriented in the same relative position. The major keying device shall be near the 12 o'clock position.

- Labels shall be provided on fuse and circuit breaker panels to indicate the rating and function of each fuse and the function of each circuit breaker.

- Fuses shall be readily accessible for replacement.

- Panel-mounted indicator light bulbs shall be replaceable from the front of the panel. Bulb-test capability shall be incorporated in the circuit design.

- Permit rapid visual inspection of all parts and components that are most likely to fail and that could cause personnel hazards if they fail during use.

- Where adjustment may be required, all cams, gears, pulleys, etc., mounted on a shaft shall be secured to the shaft by two hex socket set screws located approximately 90° to 135° apart. Where adjustments are not required, these items shall be secured with a keyway and a pin.

NOTE: The maintenance concept is specified in subparagraph 3.5.1 of the Prime Item Development Specification.

Background and Sources (Item c): This is a further clarification of paragraph 20.3.2.4 of MIL-STD-490 (page 34) and paragraph 3.2.4 of MIL-T-81821.

Paragraph 3.2.4 of MIL-T-81821 states:

> "Maintainability requirements shall be in accordance with MIL-STD-470, except that there shall be no requirement for a written maintainability program or plan or a design and evaluation plan prepared specifically to satisfy the requirements of MIL-STD-470. However during the design drawing review, the procuring activity will review the contractor's maintainability considerations for compliance with the requirements specified herein ...."

Also see AFHRL-TP-84-49, paragraph 2.5.2.3, for a discussion of factors that may improve maintainability.

Lessons Learned: A common factor contributing to the ease or difficulty of simulator maintenance has been the clarity and completeness of documentation. At one Naval base, a simulator was deemed difficult to maintain, apparently because spare parts were often unavailable. Other factors contributing to the ease/difficulty of simulator maintenance have been ease/difficulty in getting to damaged or malfunctioning parts, and ease/difficulty in removing and replacing parts.

3.2.4.1 AVAILABILITY.

"The availability of the maintenance trainer shall be a minimum of: ____
____."

Rationale and Guidance: Availability of the trainer is often more critical than reliability and maintainability. Paragraph 3.2.3 of MIL-T-81821 states:

> "Design reliability requirements for trainer peculiar items shall provide the MTBF factor needed in meeting the availability requirement ... A formal reliability demonstration is not required; however, failure to meet the reliability and trainer availability factors ... during the applicable warranty period shall be subjected to corrective action ...."

Thus, it has often been suggested that MTBF be computed by first determining availability. Availability can be determined by considering the proposed usability of training (e.g., operational hours per year, student flow, etc.).

Performance Parameters: Enter minimum availability factor: The following formulas can be used:

$$A = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

Source: paragraph 3.2.1.7 of MIL-T-81821 ("... shall be a minimum of nine-tenths [0.9]").

$$A = \frac{\text{UPTIME}}{\text{ACTIVE TIME}}$$

where:

UPTIME = That portion of Active Time when the item is performing its intended mission or is considered to be in condition to perform its intended mission or is in such condition except that servicing, preventive, miscellaneous or other maintenance tasks authorized by the using command may be performed; and, unless the item is one which has failed and is part of a function with redundancy, Uptime shall continue unless the entire function is declared by the using command to be inoperative in order to perform the required mission.

ACTIVE TIME = That time (including downtime) during which the trainer is assigned to a specified organization for the purpose of performing the organization mission.

Background and Sources: Requirement originates from paragraph 3.2.1.7 of MIL-T-81821.

Lessons Learned: In a recent study, a set of current simulators were found to be available for training at least 85 percent of the time.

3.2.4.2 FAULT ISOLATION.

"a. A fault isolation system for the maintenance trainer shall be provided and shall isolate replaceable units (RUs) where an RU is defined as: ____________ ____."

"b. The system shall be designed such that all faults can be isolated to an RU."

"c. Isolation requirements are further specified in subparagraph 3.2.4.2.1 of this specification."

Rationale and Guidance: This subparagraph and the following two subparagraphs, along with subparagraph 3.5.1 of the Prime Item Development Specification, are an attempt to specify (and clarify) the maintenance concept of the trainer (not the maintenance concept of the operational equipment being simulated).

This particular subparagraph stipulates that a fault isolation system of the maintenance trainer shall be provided, and it defines as precisely as possible a replaceable unit (RU) on the trainer (not on the operational equipment being simulated).

Performance Parameters: In the space provided, supply a definition of RU. A review of Military Standards and Specifications suggested the following definition:

> "Any item or unit whose removal from the trainer and replacement with a like serviceable unit or item at the organizational or intermediate levels shall be considered a replaceable unit (RU)."

In addition to supplying a definition, it is advisable to give specific examples; e.g., the following types of units should be considered RUs.

- A printed circuit card.
- A panel and associated logic.
- Power supplies.
- Instruments (displays).
- Mechanical controls.
- Disk pack (or diskette).

Background and Sources: This is a further clarification of paragraph 20.3.2.4 of MIL-STD-490 (page 34).

Lessons Learned: The definition of an RU which is offered is consistent with the current military maintenance concept. It is intuitively obvious that it might be beneficial to the contractor or vendor to give examples of those items or units which would not be acceptable as RUs.

3.2.4.2.1 ISOLATION REQUIREMENTS.

"a. The fault isolation system shall isolate faults to the RU limits specified within this subparagraph (item c below)."

"b. The isolation system shall function such that the isolation shall be accomplished within _______ minutes."

"c. The RU limits shall be: ________________________
____."

Rationale and Guidance: This subparagraph is an attempt to list the specific isolation requirements and RU limits.

Performance Parameters: To complete the blank in item b, enter the maximum time allowable for isolation of the fault. To determine this maximum time, consider the following factors:

- Utilization of the maintenance trainer (time available to isolate).

- Specified downtime.

- Complexity of equipment.

- Skill level of proposed maintenance personnel.

This requirement is included in the specification to provide guidance to the contractor or vendor.

To complete the second blank, enter any specific limits, such as:

- All faults in power supplies shall be correctly isolated to the failed power supply.

- ______ percent of faults (other than power supply faults) shall be isolated to the failed RU with ____% probability of correct isolation.

- ______ percent of faults (other than power supply faults) shall be isolated to one or two RUs with ____% probability of correct isolation.

- ______ percent of faults (other than power supply faults) shall be isolated to within five RUs with ____% probability of correct isolation.

The percentages and probabilities should be specified considering:

- Skill level of proposed maintenance personnel.
- Complexity of trainer.
- Probability of failures for a given RU.

Background and Sources: This subparagraph is a further clarification of paragraph 20.3.2.4 of MIL-T-81821.

Lessons Learned:

3.2.4.3 BUILT-IN TESTS, SELF-TESTS, AND DIAGNOSTIC TESTS.

"The maintenance trainer test requirements shall be as follows: ____
____."

Rationale and Guidance: This subparagraph, to a large extent, is a further clarification of the COMPUTATIONAL SYSTEM specified in subparagraph 3.1.3 and subparagraphs 3.7.2.2.2.4 and 3.7.2.2.2.4.4 of the Prime Item Development Specification. If the Built-In Tests (BITs) are fully described in these subparagraphs, then this subparagraph (subparagraph 3.2.4.3) can be deleted. However, before deleting this subparagraph in its entirety, the preparer should read the Performance Parameters section of this subparagraph.

Performance Parameters: Consider the following wording (source Specification No. 16PS028A, page 13):

> "Three types of testing shall be provided: (1) Built-In Tests (BITs), (2) Self-test and calibration tests, and (3) Diagnostics. Built-In Tests supplied as an inherent feature of selected hardware shall be used to the maximum extent practical. Additional BIT capabilities developed specifically for the trainer shall monitor only the hardware components critical to the operation of the trainer computational system. All BITs shall operate as a continuous self-test which is executed during the idle times of an operational program. The self-tests and calibration tests shall be loadable and executable for the idle times of an operational program. The self-tests and calibration tests shall be loadable and executable for the purpose of verifying operational readiness of the trainer. Any required operator participation in self-tests shall be straightforward and limited to the setting of switch or control positions and observation of lights, meter movements, etc. Self-test shall utilize BIT capabilities when supplied as an inherent feature of selected hardware. Diagnostics tests shall be selectable and executable to further isolate failures indicated as a result of self-test loading and execution."

In addition to the above wording, the preparer might find it convenient to specify the nature of the built-in test panels and switches; e.g.,

> "The panels or other features solely related to the self-test function of the trainer shall be designed for easy access and use without detracting from or interfering with the fidelity requirements specified herein."

This requirement may be critical to the student. It is not desirable to have the Built-In Test panel look as if it were part of the equipment being simulated. If it were to look like part

of the equipment being simulated, some negative transfer could occur; e.g., the student may be confused concerning which panels and switches are related to the actual equipment and which are related to the self-testing panel. It is recommended that this latter wording be placed in the specification regardless of the description inserted in subparagraphs 3.7.2.2.2.4 and 3.7.2.2.2.4.4.

Background and Sources: The first paragraph suggested in the Performance Parameters section originated from Specification No. 16PS028A. The second paragraph suggested above (the one concerning the test panel not interfering with the fidelity of the trainer) originated from experience with maintenance trainers.

Lessons Learned: Built-In Tests are very useful to maintenance personnel (those responsible for maintaining the trainer). However, it is critical that the test panel does not interfere with the fidelity level of the trainer. It is for this reason that the second paragraph suggestion in the Performance Parameters section above was offered.

3.2.5 ENVIRONMENTAL CONDITIONS.

"The maintenance trainer, including all the components, shall be designed for operation and storage within the following limits:

a. Operational

(1) Temperature: ______ to ______ °C.

(2) Relative Humidity: _____ to _____ percent (non-condensing) at _____ °C.

(3) Atmospheric pressure: sea-level to _____ meters altitude.

b. Non-Operational

(1) Temperature: ______ to ______°C.

(2) Relative Humidity: ______ to ______ percent (non-condensing) at _____°C.

(3) Atmospheric pressure: sea-level to _____ meters altitude."

Rationale and Guidance: Notice that degrees are required in metric units (degrees Centigrade). The preparer should consider placing the U.S. standard units (Fahrenheit) in parentheses.

The purpose of this subparagraph is to communicate to the contractor or vendor the typical classroom environment in which the trainer will be used, as well as the typical transporting and storage environments.

Performance Parameters: Enter required information. For the operational environment, enter the ranges expected for the facility that will house the trainer. If unknown, use the following:

Typical Classroom

Temperature: 14°C to 30°C.
Relative Humidity: 20% to 90% at 21°C.
Altitude: sea-level to one (1) mile.

To convert feet to meters, multiply feet times 0.3048. To convert F° to C° use the following formula:

$$C^\circ = 5/9\ (F^\circ - 32)$$

NOTE: Relative humidity is often specified at 90 percent condensation due to temperature change and instead of altitude, barometric pressure is often specified (e.g., 31.35 to 24.9 inches of mercury - to convert inches of mercury to kilograms per square meter, multiply inches of mercury by 345.3).

When completing the non-operating condition blanks, select the most severe conditions of transporting or storage, or any combination of both.

Background and Sources: This requirement originates from MIL-STD-490 (paragraph 20.3.2.5, page 35) and MIL-T-81821 (paragraph 3.2.5). The typical classroom conditions offered above originated from MIL-T-81821. Also see AFHRL-TP-84-49, paragraph 2.2.7, for information on logistics factors associated with facility environmental control.

Lessons Learned: At one Air Force Base, the frequent downtime of their simulator was attributed to high heat and humidity resulting from a faulty air conditioning system in a classroom.

3.2.5.1 OTHER ENVIRONMENTAL CONDITIONS.

"The maintenance trainer shall meet the following addition environmental condition requirements: ________________ ____."

Rationale and Guidance: Sometimes maintenance trainers are used in unusual environments. This subparagraph provides an opportunity to specify these conditions.

Performance Parameters: Ranges or parameters for the following conditions should be specified, if appropriate:

- Fungus.
- Vibration.
- Dust.
- Salt, Fog, or Spray.
- Acceleration.
- Shock.
- Electromagnetic force (see subparagraph 3.3.2 of the Prime Item Development Specification).
- Rodent protection and vermin control.

Background and Sources: This is a further clarification of paragraph 3.2.5 of MIL-STD-490 (page 34).

Lessons Learned: If this application involves photographic slides, magnetic tapes, or diskettes, the following exception should be entered:

> "________________________________ shall not be required to comply with the storage and transportation requirements specified herein. Applicable warnings shall be included in the trainer instructions for storage and transportation of these items."

3.2.6 TRANSPORTABILITY.

> "a. Design for transportation shall be based on an expected relocation of the trainer on a _____ basis during its life expectancy."
>
> "b. The maintenance trainer transportability requirement shall be: ________________________________
> ________________________________."

Rationale and Guidance: The transporting environment has been specified in subparagraph 3.2.5 of the Prime Item Development Specification. This subparagraph should be reserved for:

- Communicating to the contractor or vendor how often per year the trainer is expected to be relocated.

- Specifying who has responsibility for initial transportation.

- Specifying the mode of transportation (if the Air Force intends to transport the trainer either initially or during the life expectancy).

- Specifying any other requirement.

This subparagraph should be completed only if the proposed trainer is to be portable.

Performance Parameters: The blank in item a is completed by entering the expected relocation basis (e.g., semiannually, annually). For additional guidance see subparagraph 6.3 of ISD-Based Training Equipment Design Specification.

Enter in the blank for item b any special requirement:

- Specify who has responsibility for initial transportation.

- Specify mode of transportation (see MIL-T-81821, paragraph 3.2.6 and MIL-A-8421).

- Specify any other requirements (see DOD INST. 3224.1).

Consider the following wording:

> "The trainer shall be transported as specified in the contract. Adequately located and strengthened tie-down points shall be provided. Hoisting or lifting provision shall be included in the design."

Background and Sources: Above text offers sources. This requirement originates from MIL-T-81821, paragraph 3.2.6. Also see AFHRL-TP-84-49, paragraphs 2.2.2.12a, b, c, and d, and 2.2.2.13a, for a discussion of logistics support factors associated with simulator transportation.

Lessons Learned:

3.2.6.1 DISASSEMBLY FOR SHIPMENT.

"____
____."

Rationale and Guidance: This subparagraph should be used only if the size and weight limitations specified in subparagraphs 3.2.2.1 and 3.2.2.2 of the Prime Item Development Specification severely limit trainer design.

Performance Parameters: Consider the following wording (adapted from MIL-T-81821):

> "In the event the size and weight requirements specified in this specification severely limit trainer design for optimum training capability or would result in excessive costs, consideration shall be given to the feasibility of partial disassembly of the trainer for shipment purposes. When partial disassembly of the trainer for shipment purposes is required, appropriate disassembly instructions shall be included along with the trainer."

Background and Sources: MIL-T-81821. Also see AFHRL-TP-84-49, paragraph 2.2.2.12a and b, for information on logistics support factors associated with trainer assembly/disassembly.

Lessons Learned:

3.2.7 DELIVERY.

> "The maintenance trainer delivery requirements shall be as follows: ____
> ____."

Rationale and Guidance: This subparagraph should contain the following information:

- Delivery location.
- Delivery date.
- Who has responsibility for checkout when delivery has been made.

Typically the delivery location will be a Government facility. Be sure to specify the exact location or address for delivery. Before delivery, the contractor or vendor should obtain the specific building number; otherwise, the maintenance trainer will be delivered to Central Receiving and it will have to be loaded and unloaded to get to the classroom. If the contractor or vendor is given responsibility to deliver the trainer to a Government facility, then the contractor or vendor should be given the responsibility to check or inspect the trainer after delivery. If the Air Force is going to accept delivery at the plant where the trainer has been fabricated, it should be so indicated in this subparagraph.

Performance Parameters: Enter delivery location (name of facility, address - including country).

Enter delivery date (day, month, year).

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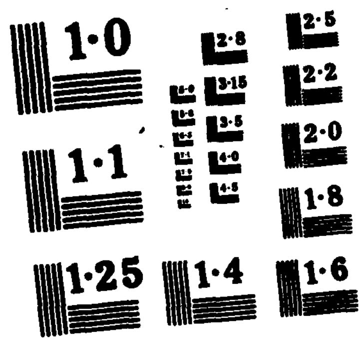
SPECIFICATION MODE..(U) APPLIED SCIENCE ASSOCIATES INC
VALENCIA PA R J HRITZ ET AL. APR 85 AFHRL-TP-84-44

UNCLASSIFIED F33615-78-C-0019 F/G 5/9 NL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Enter who has responsibility for delivery (U.S. Air Force or contractor). The information supplied in this subparagraph should be consistent with the information provided in subparagraph 3.2.6 of the Prime Item Development Specification.

Background and Sources: This is a new requirement. See AFHRL-TP-84-49, paragraphs 2.1.2.1 and 2.2.2.12a, for information on logistics factors associated with delivery.

Lessons Learned:

3.2.7.1 INSTALLATION.

"The maintenance trainer installation requirements shall be as follows: ______________________________ ______________________________."

Rationale and Guidance: This subparagraph should specify who has responsibility for installation of the maintenance trainer.

Performance Parameters: Enter who has responsibility for installation, as well as any other requirements concerning the installation (e.g., inspection after installation).

Background and Sources: This is a new requirement. See AFHRL-TP-84-49, paragraph 2.2.2 and its subparagraphs, for a discussion of logistical factors that may influence installation.

Lessons Learned: Typically the contractor or vendor is given responsibility to install and inspect the maintenance trainer.

3.3 DESIGN AND CONSTRUCTION.

"Major considerations of design and construction shall be performance, safety, availability for training, reliability, maintainability, accessibility, and life cycle cost to the Government."

3.3.1 MATERIALS, PARTS, AND PROCESSES.

"Materials, parts, and processes shall be selected in accordance with MIL-STD-143, unless otherwise specified herein. However, it is intended that the contractor or vendor be permitted maximum freedom in selecting processes, parts, and assemblies to achieve the required quality and performance at minimum life cycle cost. To permit this flexibility and retain adequate quality, the contractor or vendor shall: ______________________________ ____."

Rationale and Guidance: It is advisable to allow the contractor or vendor freedom in selecting parts, materials and processes; however, if possible, restrictions on this freedom and flexibility should be specified (if any exist).

Performance Parameters: Enter any restrictions on the intended freedom and flexibility. Possible restrictions, limitations, or instructions are offered below:

"To permit this flexibility and retain adequate quality, the contract shall:

a. Require no approval prior to inclusion in the design of trainer from specification and standards of MIL-STD-143, Group I.

b. Require written approval of the procuring activity for selection of material and process from specifications and standards of MIL-STD-143, Groups II, III, and IV.

c. Require approval from the procuring activity to use nonstandard parts prior to initial procurement."

Background and Sources: See AFHRL-TP-84-49, paragraph 2.7.2.4, for information on the logistics implications of non-standard parts.

Lessons Learned: Allowing freedom and flexibility has worked well in the past.

3.3.1.1 PARTS CONTROL PROGRAM.

"The parts control program shall be: ____."

<u>Rationale and Guidance</u>: Parts control programs vary across acquisition programs. The parts control program shall be specified in this subparagraph. MIL-STD-965 should be consulted before preparing this section.

<u>Performance Parameters</u>: If the preparer agrees that the requirements in MIL-STD-965 are applicable for the current situation, then the following can be done:

- Option 1. Direct reference can be given to all the applicable paragraphs and subparagraphs of MIL-STD-965.

- Option 2. The appropriate paragraphs of MIL-STD-965 can be directly inserted into this subparagraph of the Prime Item Development Specification.

Option 2 above is the recommended approach. It avoids having the contractor or vendor look up the necessary information. However, if option 1 is selected, the common phrasing appears to be:

"The parts control program shall be in accordance with MIL-STD-965 paragraph 4.3.1 unless otherwise specified herein."

<u>Background and Sources</u>: Only the applicable paragraphs of MIL-STD-965 should be referenced.

<u>Lessons Learned</u>:

3.3.1.1.1 SELECTION OF PARTS.

"In addition to the requirements specified in paragraph 3.3.1.1 of this specification, the following requirements shall apply: ____."

<u>Rationale and Guidance</u>: This subparagraph should be completed if subparagraph 3.3.1.1 of the Prime Item Development Specification specified a blanket reference to a Military Standard or Specification.

Performance Parameters. The following additional requirements have been included in other specifications or documents and are offered for your consideration:

- All parts to be included in the Program Parts Selection List (PPSL) shall require that the part, whether standard or nonstandard, be currently manufactured by one or more U.S. sources.

- Nonstandard semiconductors and integrated circuits submitted for approval will be approved for use provided they are directly replaceable by a standard part currently being manufactured, or if justified, by a nonstandard part currently stocklisted and being procured by DOD. The proposed part and the replacement part shall be identified in the PPSL.

- The contractor or vendor shall maintain a file identifying the source(s) for all parts on the PPSL. The file shall be available to the Government for review.

- The following criteria shall apply to those proposed semiconductors and integrated circuits and the identified replacement parts:

  - Directly replaceable.

  - Reliability and performance of the system are not degraded when a replacement semiconductor or integrated circuit is used (equal or better in form, fit, functions, tolerances, and performance).

  - The replacement part is currently being manufactured by at least one United States contractor or vendor.

  - Drawings shall call out both the original proposed part and the identified replacement part. Spares documentation, technical orders, and other documents shall call out the preferred or recommended part.

- Request for approval to use nonstandard parts shall be submitted prior to initial procurement. Approval by the Government to use a nonstandard part waives the material, process, procedure, and standard composition requirements of this specification for that part only. The part shall not be modified to make it part peculiar.

- Samples of nonstandard parts shall be requested by the procuring activity. These samples shall be submitted in

the quantities and to the destination specified by the procuring activity (for tests and examination) (NOTE: Sample quantities can be: exceed one pound of any lubricant, 12 fuses, and six units of any other part). Sample parts shall not be returned to the contractor or vendor. When there is more than one supplier for a part, parts from each supplier shall be considered for separate submission.

It may be advisable in the text of this subparagraph to define a nonstandard part. Consider the following wording:

"A nonstandard part is an item not covered by a specification or standard listed in the DOD Index of Specification and Standards (DODISS). Such parts are commercial off-the-shelf items and, in general, are company standards."

A definition is also offered in MIL-STD-965, paragraph 3.3.1 (page 3).

Background and Sources: See AFHRL-TP-84-49, paragraphs 2.5.2.5 and 2.7.2.5, for information on logistics concerns associated with parts selection.

Lessons Learned:

3.3.1.1.1.1 PARTS DOCUMENTATION.

"Parts documentation requirements shall be as follows:

____
____."

Rationale and Guidance: Parts need to be documented for inventory purposes.

Performance Parameters: Consider inserting the following wording.

"Parts documentation to substantiate inclusion in the PPSL shall have been submitted or be available for Government review prior to parts approval and incorporation into PPSL. Parts documentation in accordance with MIL-STD-965 shall be provided when requested by the Government, for approved parts used in the training device, or for parts identified as replacement parts where such documentation does not exist within the Defense Logistics Agency (DESC, DGSC, DISC or DLSC)."

If the above wording is used, the content of subparagraphs 3.3.1.1 and 3.3.1.1.1 should be checked to assure consistency and to avoid duplication.

Background and Sources: This is a further clarification of paragraph 20.3.1.1 of MIL-STD-490 (page 35).

Lessons Learned:

3.3.1.1.1.2 PARTS CONTROL EXEMPTIONS.

"Items exempt from parts control shall be: ____________ ____."

Rationale and Guidance: The contractor or vendor should be informed of those items which are to be exempt from parts control.

It should be made clear that paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965 (pages 5 and 6) specify the following exemptions respectively:

> "Parts contained in unmodified off-the-shelf equipment used in the end item of the contract shall not be subjected to parts control procedures and listed on the PPSL ...."
>
> "Parts contained in unmodified GFE used in the end item of the contract shall not be subjected to parts control procedures ...."
>
> "Structural members and machine parts that are unique and specifically fabricated for a particular application and not adaptable to other equipments shall not be subjected to parts control procedures ...."

Paragraph 4.7 of MIL-STD-965 may be further modified by the suggestion made below.

Performance Parameters: Reference can be made to paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965; e.g., "Items exempt from parts control shall be in accordance with paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965." However, it may be advisable to include these paragraphs rather than reference them.

If this application requires the use of slide projectors, CRTs, printers, computers, etc. which are commercially available, off-the-shelf items, then specific reference to these items should be listed in this subparagraph; e.g.,

> "Items exempt from parts control shall be in accordance with paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965. In addition, the following items shall be considered off-the-shelf items and thus covered under paragraph 4.7 of MIL-STD-965: Computers and directly associated peripheral devices (such as printers, keyboards, disk drivers) not specifically designed for use with the training device, CRT display systems not specifically designed for use with the trainer, and random access slide projectors not designed specifically for use with the trainer."

Background and Sources: This is a further clarification of paragraph 20.3.1.1 of MIL-T-81821 and MIL-STD-965, paragraph 4.7 (page 5).

Lessons Learned: Although MIL-STD-965 paragraphs 4.7, 4.8, and 4.9 exclude certain items, they also exempt these items from being listed in the PPSL. Thus, it might be advisable to add the following:

> "The above exempted equipment shall be identified and listed in the PPSL under an appendix section titled 'Exempt Equipment'."

In addition the following provision may be included:

> "Items not included in the above categories but considered by the contractor or vendor to be candidates for parts control exemptions shall be submitted with specific justification, on an individual basis, to the procuring activity for approval."

3.3.1.2 CONDUCTOR IDENTIFICATION.

> "Conductor identification requirements shall be as follows: ____
> ____."

Rationale and Guidance: The reason conductors need to be marked is to track the conductor when testing and isolating faults on the trainer and to allow ease of assembly and disassembly.

Performance Parameters: Any identification scheme that allows tracking should be permitted. The standard color and numbering codes are offered in MIL-STD-681.

The following requirements should also be considered:

- All conductors which are coded shall follow the same pattern throughout the equipment.

- Cables shall be identified showing the "To - From" termination points.

- Whenever practicable, the coding selected for a particular circuit should follow through connectors, plugs, and receptacles, or interconnecting circuits.

- The identification method used shall not damage the conductor and shall be located such that shielding ties, clamps, or supporting devices will not have to be removed in order to read the identification.

- The following shall be exempt from the above:

  - Wires attached by screws or nuts, where the termination point of the wire is obvious and unmistakable should it be removed for service.

  - Wires attached by screws or nuts, where two or more wires could be connected interchangeably without altering the electrical circuit (e.g., all connect to ground).

  - Point-to-point wiring.

  - Wires terminating with soldered connections (other than lugs), taper pins, wire wrap, or termipoint.

- Identification markings shall be permanent and legible. The marking in plastic on metallic materials shall be accomplished by ink stamping, embossing, engraving, silk screening, or stenciling with a smudge-proof ink.

Background and Sources: Standards for color and numbering codes are offered in MIL-STD-681.

Lessons Learned:

3.3.1.3 TERMINAL ENDS.

"Terminal ends shall have the following requirements:

____
____."

Rationale and Guidance: For tracking and isolation purposes terminal ends need to be marked or identified.

Performance Parameters: Consider the following requirements:

- "Jacket cables and hook-up wire harness shall be marked for identification by use of tubing markers in accordance with MIL-I-631. Type ______, Grade ______, Form ______, and Class ______.
- "Color-coded ribbon cable shall be exempt from the above requirement when the ends of both originate and terminate in flat cable connectors. 'To - From' information shall still be required."
- "Where space limitations prohibit marking on the terminal (strip on board), the marking shall be on the chassis adjacent to the terminal."

Background and Sources: MIL-I-631.

Lessons Learned:

3.3.1.4 SPARE CONDUCTORS.

"a. Provisions for spares shall be: __________________
____."

"b. The following shall be exempt from the requirements above: ____
____."

There are two blanks to be completed, each is discussed below:

Rationale and Guidance: The intent of this requirement is to establish built-in spare conductors for the purpose of future modifications to the trainer. Particular attention must be paid to supply adequate spare conductors in the areas where accessibility to wires is restricted and modification is likely (see subparagraph 4.3.3 of the ISD-Based Training Equipment Design Specification). In areas where expansion or modification is highly improbable, exceptions may be requested.

Performance Parameters: Consider the following phrasing to complete the first blank:

> "All cables or harnesses terminating in connections or terminal strips which contain three or more live conductors shall be provided with spare conductors as listed below. The quantity of spare conductors shall be determined from the total complement of parallel conductors having common to-from points. The spare capacity requirement for flat ribbon cables may be met by providing additional parallel flat ribbon cables. All spare conductors shall be at least the length of the longest conductor in the cable or harness branch."

No of Live Conductors	3 to 5	6 to 12	13 to 20	21 or more
No of Spare Conductors	2	3	4	5 or 20% (whichever is greater)

In the second blank list any exceptions or exemptions from the provisions stated in item a; e.g., "Power distribution cables or point-to-point wiring, such as back planes."

In addition, in the second blank a provision should be made for the contractor or vendor to request exceptions; e.g., "The contractor shall be required to request exceptions from the requirements for spare conductors prior to or at the Critical Design Review."

Background and Sources: None available.

Lessons Learned:

3.3.1.5 FINISHES AND PROTECTIVE COVERINGS.

> "The finishes and protective coverings requirements shall be as follows: ________________________________
> ____."

Rationale and Guidance: Finishes and protective coverings are specified for safety, appearance, and deterioration reasons.

Performance Parameters: Consider the following list of requirements:

- Appearance (e.g., color). Do not make the provision that the end item equipment shall be the same color as the actual related end item. For training purposes the color may be different (see the fidelity paragraph).

- Personnel safety (e.g., all walking surfaces that are part of the trainer shall be finished with non-skid materials).

- Protection against corrosion and other deterioration (e.g., delamination due to absorption of moisture of laminated finishes; finishes that will crack, peel, chip, or scale should be avoided). The provision should be made that any protective covering against deterioration should in no way prevent compliance with the performance requirements of this specification.

- Application of finishes (see FED Spec-TT-L-32).

- Also see MIL-STD-808 (for specific requirements).

- All display panels surfaces shall be treated to eliminate distracting light reflections and glare.

- All exposed edges shall be free from rough marks, scoring, etc. caused by machining.

- Materials that are nutrients for fungus shall not be used, where it is practical to avoid them. Where used and not hermetically sealed, they shall be treated with fungicidal agents that will render the resulting exposed surface fungus-resistant. Fungus resistant materials shall conform to Requirement 4 of MIL-STD-454.

- Brazing of steel, copper, copper alloys, nickel, and nickel alloys shall be in accordance with MIL-B-7883.

- In preparation for painting, after all machining, welding, and brazing operations are completed, the exterior and interior surfaces of all enclosures shall have all rust or other visible corrosive products and flux removed and shall be thoroughly cleaned of all grease, oil, and dirt by solvent wiping, vapor degreasing, or caustic washing and rinsing. Painting shall be in accordance with MIL-F-14072.

The preparer should select requirements based upon the information provided in subparagraphs 3.2.5 and 3.2.5.1 of the Prime Item Development Specification.

Background and Sources: Sources are identified above. Also see the following: Paragraphs 3.3.1.3, 3.3.1.4, 3.3.1.5, 3.3.1.6, 3.3.1.6.2, and 3.3.1.6.3 of MIL-T-81821.

Lessons Learned: Do not specify any unnecessary requirements; all specified requirements must be justified in terms of the environment in which the trainer shall be used.

3.3.1.6 POWER.

3.3.1.6.1 PRIMARY POWER SOURCE.

"The maintenance trainer shall be designed to operate from the following power source(s): ________________
____."

Rationale and Guidance: The maintenance trainer may be used in varied environments, requiring varied power sources; e.g., different countries may have different power source requirements.

If a single maintenance trainer is going to be used in different countries with different power supplies, provisions should be made for the same trainer to be used in such electrical power source environments; e.g., through adaptors or conversion units (to be supplied by the contractor).

Performance Parameters: Specify the power supply of the facility which will house the trainer (if the facility is known).

For convenience the following are offered:

United States:	120/208 VAC, 60 Hertz 3 phase wye connected 4 wire, 30 amps per phase
Belgium:	220 (±5%) VAC, 50 Hertz, single phase [or 380 (±5%) VAC, 50 Hertz, 3 phase, 4 wire]
Denmark:	120 (+5%, -10%), 50 (±3) Hertz, single phase 15 amp fused [or 120/128 (+5%, -10%) VAC 50 (±3) Hertz, 3 phase wye or delta]

- Netherlands: 220 (±5%) VAC, 50 Hertz, single phase [or 380 (±5%) VAC, 50 Hertz, 3 phase, 4 wire

- Norway 230 (±5%) VAC, 50 Hertz, single phase (or 230 VAC, 50 Hertz, 3 phase, 3 wire)

If the equipment is operated from mobile electric power-generating sources, the requirements of MIL-STD-633B shall apply.

Background and Source: See the following: Paragraphs 3.2.1.11.2, 3.2.1.11, and 3.2.1.11.3 of MIL-T-81821. Also see AFHRL-TP-84-49, paragraphs 2.2.2.8, 2.4.2.5, and 2.4.2.6, for information on logistical support considerations associated with power sources and energy requirements.

Lessons Learned:

3.3.1.6.1.1 TOLERANCES.

"Unbalanced line currents in the system shall not exceed ____ per cent of the average simultaneously measured line current. The power factor measured at the primary power source of the total inputs shall not be less than _____ percent for any mode of operation. The training device shall be protected from permanent damage, alteration of characteristics, and loss of memory due to total power failure."

Rationale and Guidance: There are two blanks to be completed: the percent of unbalanced line current and the percent power factor.

Performance Parameters: A value of 75 percent for the first blank and 80 percent for the second value is suggested. Unless other values can be justified, the suggested values should be used. The suggested values would meet the desired efficiency on a 3-phase system.

Background and Sources: See AFHRL-TP-84-49, paragraph 2.2.2.9, for information on logistics concerns associated with simulator power tolerances.

Lessons Learned:

3.3.1.6.2 CIRCUIT DESIGN.

"____
____."

Rationale and Guidance: Any requirements for circuit design should be stated here.

Performance Parameters: Consider the following: "Circuit design shall be in accordance with MIL-STD-736."

Background and Sources: See MIL-STD-736.

Lessons Learned:

3.3.1.6.3 POWER SUPPLIES.

"The maintenance trainer power supply requirements shall be as follows: ____ ____."

Rationale and Guidance: Power supplies are typically required to convert the primary electrical power service to the required electrical power of the trainer. When completing this subparagraph, consideration should be given to the mobile electric power-generating sources.

Performance Parameters: Consider the following wording:

"Solid-state electrical power supplies shall be provided to convert the primary electrical power service to the required DC electrical power."

Background and Sources: The requirements offered above originate from paragraphs 3.2.1.11.7 and 3.2.1.11.8 of MIL-T-81821 (page 16).

Lessons Learned: 400-Hz solid-state converters historically provide a high noise level and poor reliability.

3.3.1.6.4 OVERLOAD PROTECTION.

"The maintenance trainer overload protection requirements shall be as follows: ______________________________________ ____."

Rationale and Guidance: Maintenance trainers are typically sophisticated and provisions should be made to reduce any damage that might result from overloads.

In specifying these requirements, care should be taken in clarifying:

- Where fuses and circuit breakers should be used.

- Where fuses and circuit breakers should be located (i.e., they should be accessible).

- The need to have parts designed to handle or accommodate overloads.

Performance Parameters: Consider the following:

> "Circuit breakers shall be provided within the training device for primary circuits and such other circuits as necessary for protection of the equipment from damage due to electrical overload and excessive heating. Use of fuses will be permitted only when approved by the Procuring activity. All fuses and circuit breakers shall be readily accessible and replaceable by locating them directly on the front panels of the equipment. All parts that may be subjected to an overload due to circuit malfunctions, poor adjustment, or part failures shall be designed to accommodate such a load. Where parts cannot be designed to accommodate an overload, circuit breakers shall be provided to protect the unit or assembly. The training device shall be designed for protection from overvoltage, undervoltage, and phase power loss for all three phases of input."

Background and Sources: None available.

Lessons Learned:

3.3.1.6.5 UTILITY POWER.

"The utility power requirements shall be as follows:

____

____."

Rationale and Guidance: The maintenance trainer may be equipped with utility power (for utility lights, utility outlets, and for a maintenance intercom - if needed). If these items are not required, then this subparagraph can be omitted.

When completing this subparagraph, consider the kind of maintenance the trainer will require. The type of maintenance influences the need for utility power; e.g., if maintenance trainer test equipment is built in, then utility power will usually not be required unless lighting during maintenance is required; then, utility power for lighting will be needed. Also, if test equipment is to be used, identify specific interconnect cables.

Also, in this subparagraph, specify the number of utility receptacles (outlets) that shall be needed, as well as the number of utility lights. It has been suggested that as a minimum there should be at least one utility outlet and light per panel trainer. However, MIL-T-81821 (paragraph 3.3.1.21.4.1) specifies, "In the case where a trainer consists of two or more trainer panels, two utility receptacles shall be installed on each panel."

If a maintenance intercom is needed, specify the need for one.

Performance Parameters: Consider the following wording:

a. "Utility electrical power circuits shall be designed to operate from the primary main power sources and shall be operable while the remainder of the training device power is off. These circuits shall contain the utility outlets. Outlets for portable tools and equipment shall be 3-wire, grounding-type, utility duplex receptacles. Utility power circuits shall be protected with ground-fault circuit interrupters."

b. "There shall be ____ (number) receptacles, per trainer panel, located at ________________________." (Specify location; e.g., rear of trainer panel.)

c. "There shall be ____ (number) light receptacles located at ______________________________." (Location.)

d. "Utility receptacles shall be capable of carrying a 15-amp load minimum."

e. "The maintenance intercom shall ________________." (Specify requirements; if no intercom is required, delete this item.)

Also consider the following wording: "To facilitate maintenance, 60 Hz, 120-volt, grounding-typed utility receptacles conforming to W-C-596 Style D, shall be installed."

MIL-C-299025 specifies requirements for a maintenance intercommunication system.

Paragraph 3.3.1.21.4.2 of MIL-T-81821 specifies, "When applicable, two easily accessible 115V, 400 Hz power receptacles shall be provided on each trainer panel for use with system test equipment. The receptacles shall be located adjacent to the utility receptacles and shall be appropriately marked. Trainer-peculiar interconnect cables shall be provided, as required, to accommodate the test equipment."

Background and Sources: See the discussion above. Also see AFHRL-TP-84-49, paragraphs 2.4.2.5 and 2.4.2.6, for information on logistics factors associated with simulator energy requirements.

Lessons Learned:

3.3.1.6.6 MAIN POWER DISTRIBUTION PANEL.

"The main power distribution panel requirements shall be as follows: ____ ____."

Rationale and Guidance: When completing this subparagraph, consider the following:

- Circuit Design - The circuit design shall include a main power switch to shut off all power to the trainer without disconnection from the power source. NOTE: Utility circuits should be separately protected.

- Possible Equipment Damage - A main power distribution panel shall be provided and wired in such a manner as to avoid damage to equipment by activation of switches in an indiscriminate or random sequence.

- Contents of Panel - A power distribution panel shall be provided and shall contain the electrical busses and disconnects. This panel shall contain the master keyed-lock switch, elapsed time meter(s), 'Power On' light(s), warning light(s) as required (MIL-T-81821, paragraph 3.3.1.21.6).

- Location of Panel - The power control panel shall be installed in a clearly visible location (MIL-T-81821, paragraph 3.3.1.21.6).

- Number of Power Control Panels - Each trainer, independently operable trainer panel, and panel group which requires external electrical, hydraulic, or pneumatic power shall be provided with a power control panel (MIL-T-81821, paragraph 3.3.1.21.6).

Performance Parameters: Select the appropriate wording from the above paragraph. If certain items are contained on the panel,

they should be further clarified. Consider the following wording when specifying these:

Master Keyed-Lock Switch - "A master keyed-lock switch shall be provided on each trainer power control panel to control the availability of power from components of the trainer panel. Power for the test equipment receptacles on the trainer panel shall bypass the master keyed-lock switch. The switch or circuit breaker shall return to and remain in the 'OFF' position in the event of power interruption. The switch shall be marked as specified herein." (MIL-T-81821, Paragraph 3.3.1.21.6.1.)

If a master keyed-lock switch is not going to be used, then specify the protect instrument (e.g., enter a code in the provided keyboard).

Power-On Light - "A separate one- (1) inch-diameter red pilot light for each type of electrical, hydraulic, and pneumatic power required shall be installed on each trainer power control panel in a clearly visible location. The light(s) shall be appropriately marked to indicate 'POWER ON' for the master switch, and for each type of power required for the trainer panel. The light(s) shall illuminate when the applicable type of power is available on the trainer panel." (MIL-T-81821, paragraph 3.3.1.21.6.4.)

NOTE: Time totalizers are specified in subparagraph 3.3.1.8 of the Prime Item Development Specification.

Background and Sources: Sources are referenced in the above two paragraphs.

Lessons Learned:

3.3.1.6.7 POWER INTERRUPTION AND TRANSIENTS.

"a. The maintenance trainer shall be protected from permanent damage and modification of characteristics and loss or change of computer-stored memory information resulting from the following nonsimultaneous conditions of power sources: ______________ ____."

"b. The design of the trainer shall be such that when a power interrupt occurs which causes an equipment shutdown, the point at which the training was interrupted shall be identified."

Rationale and Guidance: Power interruptions can cause problems for and damage to the trainer. It is not necessary for the trainer to continue during a power interruption.

Performance Parameters:

- An interruption with power restored within 3 to 30 seconds occurring not more than once every 5 minutes.
- A voltage transient of three and one-half (3.5) times nominal voltage to one-tenth (0.1) of normal voltage but short duration (less than one cycle).
- A frequency variation of plus or minus 15 percent for periods up to 10 seconds occurring not more than once every 5 minutes.

Background and Sources: See AFHRL-TP-84-49, paragraph 2.4.2.12, for a discussion of the logistics implications of power interruptions.

Lessons Learned:

3.3.1.6.8 GROUNDING.

"The grounding requirements shall be as follows: ______
____
____."

Rationale and Guidance: This subparagraph is included for safety consideration as well as for the proper operation of the trainer.

Performance Parameters: MIL-T-81821, paragraph 3.3.1.24.2 specifies the following:

"All non-current-carrying conducting materials such as metallic conduit, cable sheath or armor, enclosures, and switch boxes, which could short to potentials greater than 30 V, shall be electrically bonded and connected to a common ground bus, which shall be connected to the grounding terminal of the power input receptacle."

The following are additional requirements:

"Primary power circuits shall not be directly grounded within the training device. All neutrals shall be made common at the power source neutral bus. The neutral bus of the power sources shall be routed through equipment power panels to earth potential at one point."

"Where required, power line interference filters shall be referenced to chassis ground. Power line interference filters shall meet the electromagnetic compatibility requirements specified within this document."

"Signal frequencies of 150 kHz or less and pulsed signals with rise and fall times equal to or greater than 5 microseconds shall utilize a grounding system insulated from the chassis and prime power ground within the training device. Analog systems which have frequencies less than 20 kHz shall use a grounding system that is referenced to a single point to avoid duplicate and common signal ground return paths."

"Signal frequencies greater than 150 kHz and pulsed signals with rise and fall times of less than 5 microseconds may utilize chassis as signal ground. Signal interfaces with equipments not in this category shall be properly isolated to ensure noncompromise of the lower-frequency equipment signal ground system. High-frequency grounding (bonding) straps shall have a length-to-width ratio of 5:1 and a minimum thickness of 0.025 inch."

"Cabinets, consoles, racks, and equipment shall have a signal ground point isolated from chassis. The signal ground point shall be located less than 2 inches from the chassis ground point. The junction resistance between the signal ground bus and a signal ground point shall not be greater than 0.5 milliohm."

"Equipment cases, cabinets, racks, and enclosures shall be referenced to the chassis grounding system. The chassis grounding system shall provide for a fault-current return path for personnel shock hazard safety and a low impedance path for currents for the training device electrical or electronic equipments. The resistance between any two chassis ground interfaces shall be less than 5.0 milliohms. Plugs and convenience outlets for use with portable tools

and equipment shall have provisions for automatically grounding frame, case, or housing of tools and equipment, for personnel shock hazard safety, when the plug(s) are mated with receptacle(s) that conform to W-C-596."

"Cable and wire shield grounding termination practices shall be consistent with the frequencies and the interference and susceptibility levels of wires and cables being shielded. The following shield grounding methods shall be used:

a. Shields used for low-frequency signal lines shall be terminated at one end only.

b. Shields used for high-frequency signal lines may be terminated at each end.

c. Coaxial cable shields for low-frequency, low-level signal lines shall be floated from chassis.

d. Conduit and external metallic sheath used for overall cable shielding shall be terminated to chassis ground at each end by direct contact around the periphery of the shield.

e. Shields used for restricting high-frequency interference and relay lines shall be terminated to chassis ground at each end."

Background and Sources: See AFHRL-TP-84-49, paragraph 2.2.2.9, for a discussion of the logistics factors associated with grounding requirements.

Lessons Learned: Many hard-to-find electrical problems have been attributed to poor grounding practices.

3.3.1.6.9 WIRING, GENERAL.

"____
____."

Rationale and Guidance: There should be a general statement concerning wiring.

Performance Parameters: MIL-T-81821 specifies the following: "Specification MIL-W-5088 shall be used as a guide for wiring trainer panels. The wiring shall be equal to the best commercial standards and adequate for the trainer requirements."

The preparer should carefully review MIL-W-5088 to determine if all paragraphs are applicable.

Background and Sources: Above discussion specifies source.

Lessons Learned: Many contractors or vendors have mistakenly used undersized wiring.

3.3.1.6.9.1 WIRING REQUIREMENTS.

"The wiring requirements shall be as follows: ____________ ____."

Rationale and Guidance: Consideration should be given to the following requirements. These requirements can be specified within this subparagraph or they can be separated into their own subparagraphs:

Wire Bundling.
Shielding
Wiring and Cabling/Cable Classification.
Insulation Protection.
Cable Support.
Printed Wiring.
Electrical Connectors.

Information on each of these is offered in the discussion below.

Performance Parameters: Each of the above items is discussed:

- Wire Bundling: MIL-T-81821, paragraph 3.3.1.29.1 specifies the following:

  "All wiring shall be neatly bundled. Continuous lacing shall not be used for bundling. Wiring or bonding which is not typical of the related end item shall be hidden from the students' view, preferably behind the trainer panel, or concealed in an existing harness."

- Shielding: MIL-T-81821, paragraph 3.2.1.30, specifies the following:

  "Shielding shall be provided to protect sensitive, low power level circuits against the electromagnetic interference effects of conducted or radiated radio frequency energy whether internally or externally generated. Shielding shall not prevent replacement of defective wafers."

Also consider the following statement:

"Conductors using metallic shielding unprotected by an outer insulation shall be secured so as to prevent the shielding from coming into contact with exposed terminals or conductors. Shielding shall be terminated at a suitable distance to ensure adequate insulation from the exposed conductor to prevent shorting or arcing between the conductor and the shielding."

- <u>Wiring and Cabling:</u>

  "Wire and cabling routing shall provide the isolation requirement specified herein. Interconnecting cables between cabinets and enclosures shall enter from the rear, top, or bottom of cabinets or enclosures."

- <u>Cable Classification:</u>

  "Interference-producing or interference-sensitive wires and cables classified below shall meet the electromagnetic interference (EMI) criteria specified herein:

  a. <u>Class I</u> - Class I consists of wires and cables between equipments or circuits that are not interference-producing. Examples of this class are:

     (1) AC power wiring.

     (2) Relay and stepping-motor wiring.

     (3) Actuating power wiring.

     (4) Flashing incandescent and fluorescent light wiring.

  b. <u>Class II</u> - Class II consists of wires and cables that, in themselves, are not interference-producing but are connected to interference-sensitive equipments or circuits. Examples of this class are:

(1) Microphone circuits.
(2) Audio and video outputs.
(3) Metering and bridge circuits.
(4) Transducer outputs.
(5) DC and AC reference voltages
(6) Receiver inputs.

c. Class III - Class III wiring consists of wires and cables that are connected to equipments that are both interference-producing and interference-sensitive. Examples of this class are the Pulse Inputs and Outputs of digital equipment.

d. Class IV - Class IV wiring consists of those wires which carry classified information."

. Insulation Protection:

" Where wires are run through holes in metal partitions (shields and the like) less than one-eighth (1/8) inch in thickness, the holes shall be equipped with grommets for mechanical protection of the insulation. Holes in panels of one-eighth (1/8) inch or more in thickness shall either have grommets or the hole edges shall be rounded to a radius equal to one-half (1/2) of the thickness of the panel. Grommets for wires operating at RF potentials shall be of ceramic, styrene, or phenolic material, except for coaxial cables, where rubber or neoprene grommets are acceptable."

MIL-T-81821, paragraph 3.3.1.24.5 specifies:

"Wherever electrical wiring is routed through holes in material less than one-eighth (1/8) inch in thickness, the holes shall be equipped with suitable grommets for protection of insulation subject to abrasion. Paneling one-eighth (1/8) inch or more in thickness shall have grommets or shall have the hole edges rounded to a radius equal to one-half (1/2) the thickness of the material. Care shall be exercised in the support and routing of hookup wiring to ensure that it is not carried over or bent around any sharp corner or edge which could damage the insulation, or routed near any sources of heat or substances which might cause accelerated deterioration of the conductor insulation."

- Cable Support: The following is suggested:

  "Conductors not placed in ducts or channels shall be bound into a cable and securely held by insulating clamps or other suitable means, except where point-to-point wiring or commercial equipment is used. Cables shall be supported at least every 24 inches to prevent abrasion from folding, vibration, or other mechanical damage. Where not contained in ducts or channels, interconnecting cables or harnesses between assemblies and units shall be contained within extruded plastic or synthetic or rubber tubing.

- Printed Wiring: The following are suggested:

  "Except as noted herein, printed wiring shall be in accordance with Requirement 17 of MIL-STD-454. For equipment used only in the environmental conditions of this specification and when circuit leakage is not critical, a solder mask meeting the Requirements of IPC-SM-840, Class III may be substituted for conformal coating."

- Electrical Connectors: The following are suggested:

  "Requirement 10 of MIL-STD-454 shall apply. MIL-C-38999 and MIL-C-83723, MIL-C-55302 and MIL-C-39012 covering circular, printed circuit board, and RF connectors, respectively, are preferred when these types of connectors are used. MIL-C-83503 shall apply for flat cable connectors."

Other possible requirements are:

- Slack:

  "For flexible conductors, including those within cables terminating in multiterminal headers or receptacles, slack shall be provided to permit not less than two

less than two replacements of the part, with the exception of radiofrequency (RF) leads, where the length must be made as short as possible for electrical reasons", or "Sufficient slack shall be provided in all wiring to permit a minimum of three (3) receptacle replacements. Connectors shall be provided at all disassembly points on trainers requiring disassembly for shipment."

This can also be phrased as (see MIL-T-81821):

"Where it has been determined that it will be necessary to relocate a radio, radar, or electrical system component from the stowage shelf for installation on the bench top for instructional purposes, sufficient length of cable or patch cords shall be provided to permit the units to be removed to the work area on the bench top without affecting their operation. Space for stowage of the extra lengths of cable or patch cords shall be provided."

- Voltage Drop: The voltage drop requirements of MIL-W-8160 shall apply.

- Current-Carrying Capacity: Current-carrying capacity of wires and cables shall be in accordance with MIL-W-8160.

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.1.7 MECHANICAL CONNECTORS.

"Mechanical connector requirements shall be as follows:

____
____."

Rationale and Guidance: Often maintenance trainers have mechanical connectors for hydraulic and pneumatic power hoses. This subparagraph provides an opportunity to specify the connector requirements.

Performance Parameters: Consider the following:

"Mechanical connections shall be supported to prevent breakage and changes in performance due to vibration,

inclination, or shock encountered under specific service conditions specified in the detail specification. Wire terminations shall be in accordance with the mechanical connections requirements of MIL-S-45743."

Paragraphs 3.3.1.33 and 3.3.1.34 of MIL-T-81821 specify the following:

"Each trainer, independently operable trainer panel, or panel group which requires the use of hydraulic or pneumatic power shall be provided with (25) foot flexible hoses, as required, for connecting the trainer panels to the facility or trainer hydraulic or pneumatic power supply system or for trainer panel interconnect, as applicable. Appropriate female quick-disconnect fittings, with dust covers, shall be installed in each end of each hydraulic or pneumatic hose to provide for mating with the male quick-disconnect fittings on the trainer panels and the facility hydraulic or pneumatic power supply system. When pressure and volume flow is the same, all hydraulic pressure hoses shall be interchangeable and all hydraulic return flow hoses shall be interchangeable; however, hydraulic pressure hoses and return flow hoses shall not be interchangeable with each other. When pneumatic pressure and volume flow are equal, all pneumatic hoses shall be interchangeable with each other."

"Individual trainer panels requiring external hydraulic or pneumatic power shall have hydraulic/pneumatic manifolds with appropriate male hydraulic quick disconnects or pneumatic fittings installed on the rear center of the panel, and shall be capable of conducting hydraulic or pneumatic power through the manifold connections to two (2) or more related trainer panels, with the individual trainer panel power either 'OFF' or 'ON' when connected in series from a single hydraulic or pneumatic power source. Each maintenance trainer and individual trainer panel which is not part of a panel group shall be capable of independent operation when connected to the power supply, and shall contain an appropriate control panel for this purpose. Connectors shall be provided at all disassembly points on trainers requiring disassembly for shipment."

Background and Sources: Sources are specified in the above discussion.

Lessons Learned:

3.3.1.8 TIME TOTALIZER.

"The time totalizer requirements shall be as follows:

____
____."

Rationale and Guidance: Time totalizers are used to measure time of operation, time of power-on, etc. Maintenance trainers should be provided with totalizers, so that operational costs can be computed and maintenance actions recorded.

Performance Parameters: MIL-T-81821, paragraph 3.3.1.22 specifies the following:

"Four-digit time totalizing meters conforming to MIL-M-7793 registering in 1-hour increments shall be installed on each power conversion unit to register total hours of operation and on each trainer, independently operable trainer panel and panel group as required to separately record the following where applicable:

a. A meter on the equipment side of the master keyed-lock switch to record total number of hours that power is used for equipment which is normally on stand-by when the lock switch is in the "ON" position.

b. A meter on the equipment side of the master keyed-lock switch to record the total number of hours that power is used for the actual operation of the trainer and components or equipment installed thereon.

c. A meter to register the total number of hours that power is used by the trainer for the operation of support equipment through the trainer power receptacles.

d. A meter shall be installed to record the total hours of operation of each power conversion unit.

On short cycle operations types of trainers, such as landing gear, speed brake and arresting hook trainer panels, for which hours of actual operation would not provide a meaningful measure of trainer utilization, an operational cycle counter may be substituted for the elapsed-time meter registering total hours of actual trainer operation."

Also consider the following:

"A time totalizing meter shall be utilized in the power distribution panel . . . .Time totalizing meters shall also be installed on the major subsystems which may be used independently of each other for fractions of the total trainer time. The meters shall have at least four digits in increments of 1 hour."

In some cases, a higher number of digits may be appropriate.

Also the number of totalizers should be specified; consider the following places where a totalizer might be required:

Computer.
Peripheral devices (e.g., printer).
Visual display system (e.g., slide projector). Each hydraulic pump.
Main power supply.

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.1.9 SCREW AND PIPE THREADS.

"Screw and pipe thread requirements shall be as follows: ___
____
____."

Rationale and Guidance: This subparagraph provides an opportunity to specify any requirements for threads.

When supplying the text for this subparagraph, consideration should be given to the following:

- Type of threads desired. (Do not forget about the standards in foreign countries, if the trainer is to be used in foreign countries.)

- Type of threads desired for adjustments.

Performance Parameters: Consider the following wording:

"Unless approved by the procuring activity, parts with threads other than those specified in Requirement 12 of MIL-STD-454 shall not be used."

"Threaded devices used for adjustment purposes shall conform to either the unified-coarse or fine-thread series in accordance with National Bureau of Standards, Handbook H28."

Also consider the following:

"Commercial utility parts such as: screws, bolts, nuts, washers, pins, rivets and similar small parts having suitable properties may be used provided that:

a. They can be replaced by standard parts without alteration.

b. The corresponding standard part number is referenced in the part list and on the training device drawings."

Background and Guidance: No sources are available.

Lessons Learned:

3.3.1.10 THERMAL DESIGN.

"Thermal design requirements shall be as follows: ____."

Rationale and Guidance: Heat build-up can cause severe damage to the equipment. In addition, dust within enclosed cabinets can cause severe damage to the trainer; dust can be controlled by using filters. Heat build-up requires a cooling system.

Performance Parameters: Protection of parts due to dust, soot, or insects should be considered. Consider the following wording:

"Internal parts of the training device subject to damage, change in physical characteristics, or malfunction from

the accumulation of dust, soot, insects, or other contamination shall be protected from the direct path of natural or forced air circulation by filters."

Also consider the following:

"The filters shall be either replaceable or reuseable with easy access for periodic cleaning and replacement."

For heat control, consider the following phasing:

"Thermal design of electronic equipment shall be in accordance with Requirement 52 of MIL-STD-545.

The training equipment design shall provide for part, assembly, and cabinet operation in a thermally ambient temperature, without hot spots, when operated within the temperature and environmental conditions specified in the specification. When forced air cooling is used, the following guidelines shall apply:

- Fans and blowers shall operate from the equipment power source.

- Air filters shall be located at all intakes and shall be removable to permit cleaning without disassembly of the equipment.

- Openings or ducts shall be provided to carry the exhaust air away from the unit. Where heated air may affect the room temperature, the heated air shall be exhausted outside.

- All exhaust openings shall be located at the top, rear or side of the training equipment consistent with the location of associated cabinets and equipment.

- Fans or blowers shall be placed at the intake end of the duct.

- The maximum air velocity through the enclosures shall not exceed 900 ft/min.

- Electronic equipment enclosures shall be of the ventilated type as defined in MIL-STD-108. All cabinet enclosures except those remotely located shall have air inlets for use with forced air ventilation."

The use of blowers can be further clarified with the following words: "Blowers for cooling electronic equipment shall conform to MIL-B-2307."

Regarding wattage dissipation, the following can be stated:

"Where wattage dissipation calculations indicate heat problems, the design of the affected equipment shall be governed by thermal considerations. The following are some methods of solution:

- Provide structural conductors to carry the heat to the extremities of the unit.

- Provide radiating areas and, if needed, fins to permit convection of the heat.

- Isolate heat-dissipating parts and subassemblies to prevent heat flow into adjacent parts.

- Employ completely bonded heat sinks for all heat-dissipating parts.

- Use materials and parts of proven thermal capabilities."

And finally, paragraph 3.2.1.8 of MIL-T-81821 further clarifies when cooling is required:

"Trainer panels or items of equipment containing heat-producing components shall be designed and arranged so that stabilized operating temperatures do not exceed the rated temperatures of parts, equipment, and components exposed thereto. If this cannot be accomplished, adequate provisions shall be made for the removal of heat. Where the rate of heat emission is too high to warrant reliance upon natural convection for cooling, forced ventilation shall be installed. Such ventilation shall prevent the stabilized operating temperatures of parts, components, and equipment mounted in the enclosures from exceeding their rated temperatures with an ambient air temperature of ninety degrees (90°) F. Under any condition of operation, at an ambient temperature of seventy-seven degrees (70°) F, the

temperature of exposed parts and surfaces shall not exceed one hundred and forty degrees (140°) F, except that the operating controls and control panels shall not exceed one hundred degrees (100°) F. Trainers shall be capable of operating continuously for 4 hours or for the three complete cycles of operating, whichever is longer, without overheating or damaging the equipment."

Background and Sources: Sources are referenced in the above discussion.

Lessons Learned:

3.3.1.11 FASTENERS.

"Fasteners used on the trainer shall meet the following requirements: ____ ____."

Rationale and Guidance: There are many kinds of fasteners that can be used; e.g.,

- Trainer-peculiar fasteners.
- Screws.
- Clamps.
- Locking devices.

This subparagraph provides an opportunity to specify the requirements for such fasteners.

Performance Parameters: MIL-T-81821, paragraph 3.3.1.13 discusses trainer-peculiar fasteners:

"Trainer peculiar fasteners used to secure removable components, casters, access doors and other detachable items shall require a minimum number of turns to the locked position commensurate with stress requirements. Captive type one-quarter (1/4) turn fasteners shall be used where feasible."

Also consider the following statement:

"The application of fasteners and fastenings shall be in accordance with Requirement 12 of MIL-STD-454."

Locking devices can also be specified:

"Locking devices shall be capable of retaining the controls in any given setting within the range of control. The locking and unlocking action shall not affect the setting of the control. Where verniers are used, the locking device shall operate on both main and vernier controls."

Clamps can be specified as follows:

"All plug-in electronic parts and electron tubes shall be securely retained by clamps where necessary to meet the shock and vibration requirements of the detail specification. Clamps, when used, shall be capable of being easily released for item replacement."

For flathead screws and panel-mounting screws consider the following phrasing:

"Flathead screws shall not be used in sheet or thin-walled material having a thickness of less than one and one-half times the height of the head of the screw. Wherever flathead screws are used, the screw head shall be completely seated in the material."

"Panel-mounting screws shall be limited to oval-head or recessed flush-head screws."

Background and Sources: Sources are referenced in the above discussion.

Lessons Learned:

3.3.2 ELECTROMAGNETIC COMPATIBILITY.

"The maintenance trainer shall have the following electromagnetic compatibility requirements: ______________________
____."

Rationale and Guidance: The training device must be compatible with itself and with the facility in which it will be housed.

Performance Parameters: Consider the following wording:

"The training device shall be electromagnetically compatible with itself, the other equipment in the same facility, and with the environment. Adequate shielding and circuit separation shall be designed into the training device, and where classified information will be processed, the design shall be in accordance with the guidelines of AFR 100-54. The complete training system shall comply with the conducted and radiated interference suppression requirements of MIL-STD-461 for Class B4 equipment. Abbreviations and terms used in conjunction with EMI shall be in accordance with MIL-STD-463. The requirements of MIL-E-6051 shall apply. MIL-STD-462 shall be used as a guide for testing the requirements of MIL-STD-461."

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.3 NAME PLATES AND PRODUCT MARKINGS, GENERAL.

"a. Unless otherwise specified herein, name plates and product markings shall be: ________________________ ________________________."

"b. Control panel markings shall be: ________________________ ________________________."

"c. Abbreviations used in marking shall be: ________________________ ________________________."

Rationale and Guidance: This is a header paragraph, which establishes some general requirements. Specific requirements are further presented and discussed in the subparagraphs to follow.

Performance Parameters: Item: a is typically completed by, "... in accordance with MIL-STD-130."

Item b is typically completed by "in accordance with MIL-STD-1472."

Item c is typically completed by "in accordance with MIL-STD-12."

However, before imposing such blanket requirements, the preparer should review each of the above-mentioned standards. If exemptions are indicated for this application, these exemptions should be specified.

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.3.1 NAME PLATES.

"Name plate requirements shall be as follows: ______________
____."

Rationale and Guidance: Name plates provide a means for end item identification.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.2 establishes the information requested on the name plates.

"An aluminum or brass data plate, one-eighth (1/8) inch thick, permanently and legibly engraved or stamped with the following information, shall be securely attached to each trainer panel in a Place not readily visible to the student."

Military Serial Number	*
Trainer Nomenclature	*
Panel No. * of * panels	*
Related End Item Serial No. Reflected	*
CI	*

Configuration:

	Cube	Height	Width	Length	Weight	Floor Loading With Casters	Floor Loading Without Casters	Floor Loading With Jack Pads
Operating	*cu.ft.	*in.	*in.	*in.	*lbs.	+*PSI.	*PSI.	*PSI.
Shipping	*cu.ft.	*in.	*in.	*in.	*lbs.	+*PSI.	*PSI.	*PSI.

* Applicable data shall be entered in maximum extended dimensions.
\+ Maximum single-caster load.

Manufacturer's Name and Code *
Manufacturer's Part Number *
Manufacturer's I.D. *
Federal Stock Number (when applicable) *

Name of Contractor *
Contract Number *
Acceptance Insp. Date *
Property of U.S. Government *

* Applicable data shall be entered in maximum extended dimensions.

NOTE: The Military Serial Number shall be established by the procuring activity.

NOTE: When applicable, the contractor or vendor shall obtain the Federal stock number in accordance with MIL-STD-26715.

NOTE: CI represents the Configuration Item plus a seven digit alphanumeric identifier. MIL-STD-482A, Appendix II (page II-3) specifies that the CI identifying number designates trainer under configuration management. The CI is a reference point in using configuration status and accounting documentation. For software, the prefix "CPCI" denotes Computer Program Configuration Item (see MIL-STD-483).

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.2 PARTS IDENTIFICATION.

"The parts identification requirements shall be as follows:
____
____."

Rationale and Guidance: For ease of replacement and identification, parts should be marked. Parts should be marked to the RU level.

If cards or boards are to be marked, consider using the matrix method.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.6 offers the following:

"The name of each major part or assembly shall be engraved, photographed, etched, etc., by the most economical method on suitable nonferrous material in neat, well-formed characters, one-quarter (1/4) to one-half (1/2) inch high, on standard

black-white-black engraving stock plates, or black anodized aluminum stock. The plates shall be located on or adjacent to the corresponding part. Each major part or assembly shall have identical markings and instructions on or adjacent to it as those on the actual related end item.

Also consider the following:

"Reference symbol designations shall be assigned to electrical and electronic component assemblies in accordance with ANSI Y32.16. Mechanical symbols shall be in accordance with MIL-STD-17. Symbols for electrical and electronic diagrams shall be in accordance with ANSI Y32.2."

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.3 COVER MARKINGS.

"Cover marking requirements shall be as follows: ____________
____."

Rationale and Guidance: First, it must be determined if there is going to be a cover (e.g., dust cover). If a cover is required, that cover can be described in this subparagraph or can be described in paragraph 3.7 of this specification (e.g., identify cover material such as wood or fabric and identify size of cover).

Also described in this subparagraph should be any markings that appear on the cover(s).

Performance Parameters: Specification No. 16PS028A, paragraph 3.3.3.13 provides a good example of a description of a fabric cover:

"A dust and security cover shall be provided for each unit . . . to provide protection against damage due to collection of dust during periods of non-use. These covers shall be fabricated of a light-weight fabric material, conforming to MIL-C-20696, Type 1, Class 3, Color 15102 in accordance with FED-STD-595. Covers shall be designed to fit the individual unit in both the shipping and operating configuration."

The same specification in paragraph 3.3.3.14 also provides a good description of a hard cover:

"Hard covers shall be provided for protection against weather and handling during shipment. The hard covers

shall disassemble for storage into separate units; i.e., two ends, two sides, a lid, and a base. The base shall serve as a skid and shall include forklift provisions. Casters are not required on the base unless they are demountable and stowage provisions are included in the assembled hard cover. In the event casters are provided, they shall be swivel-lock, brake-type casters. The separate units of the hard covers shall assemble through the use of mechanical locking devices such as high-strength, hexagonal wrench-operated, rotary-type latches. In no case shall assembly of the component units into a hard cover require the use of screws or nails. Means shall be provided to firmly secure the trainer unit to the hard cover base before assembling the hard cover. The remaining hard cover components shall have adequate shock-absorbing materials and/or restraint devices to immobilize the unit during transportation."

For further information concerning the construction of covers, see paragraphs 3.7.5, 3.7.5.1, 3.7.5.2, and 3.7.5.3 of MIL-T-81821.

In terms of marking, MIL-T-81821, paragraph 3.3.3.7 offers the following wording for outer covers in general:

"Applicable cover markings shall appear on both the longer sides of the upper edge of each trainer cover. Inner dust/security covers shall be marked with the appropriate security classification in red letters not less than two (2) inches high. The word FRAGILE shall be appropriately marked on each of the four sides of the outer trainer cover using red letters 2 inches high. Adjacent to these markings shall be a vertical red arrow and the legend THIS SIDE UP in letters 1 inch high. Each outer cover shall be permanently and legibly marked with the following information in three-quarters (3/4) inch high white letters:

Federal Stock Number	* (when applicable)
Military Serial Number	*
Trainer nomenclature	*
Panel No. * of * Panels	*
Configuration	*

					Floor Loading		
Cubage	Height	Width	Length	Weight	With Caster	Without Casters	With Jack Pads
*cu.ft.	*in.	*in.	*in.	*lbs.	+*PSI.	*PSI.	*PSI.

* Applicable data in shipping conditions shall be entered.
+ Maximum single-caster load.

MIL-T-81821, paragraph 3.3.3.7.1, also offers the following on security covers:

> "On all trainers classified CONFIDENTIAL or higher, the inner fabric security cover shall be marked with the appropriate security classification in red letters not less than two (2) inches high. These letters shall appear against a white or similar high-contrast background. The security classification shall not be indicated on the exterior of the outside cover."

MIL-T-81821, paragraph 3.3.3.7.2, offers the following wording concerning hard covers:

> "A weatherproof decal with instructions for removal of the hard cover and installation of the casters shall be placed on the cover near the caster access door."

MIL-T-81821, paragraphs 3.3.3.17 and 3.3.3.18, also indicate the need to have instructions for the assembly of the cover as well as the installation of the casters:

> "When hard outer covers are provided, one corner of the cover and a corresponding point on the trainer base panel shall be appropriately marked to indicate the correct installation of the cover assembly."

Also of concern may be cover handles; consider the wording suggested by MIL-T-81821, paragraph 3.3.3.18:

> "When hard outer cover handles are provided, which are not suitable for hoisting or cargo plane tiedown attachment, the following legend shall be centrally located above the handles on each side or end of the cover in red letters approximately 1 inch in height:
>
> WARNING
> FOR LID LIFT ONLY"

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.4 PRECAUTIONARY MARKINGS.

> "The precautionary marking requirements shall be as follows: ______________________________ ______________________________."

Rationale and Guidance: Precautionary markings should be used when a part from the real equipment has been modified and used on the trainer.

Performance Parameters: MIL-T-81821, paragraphs 3.3.3.9 and 3.3.3.10 offer the following wording, respectively:

> "When modified, rejected or non-operable parts are used, the trainers shall be appropriately marked by metal plate, decalcomania, etc., as follows:
>
> PARTS AND COMPONENTS OF THIS TRAINER, WHEN INDIVIDUALLY MARKED MODIFIED, REJECTED OR NON-OPERABLE, ARE TO BE USED FOR GROUND TRAINING PURPOSES ONLY."
>
> "Modified parts which by means of depot-level overhaul could be returned to Ready For Issue (RFI)/Servicable condition for operational use on the related end item shall be appropriately marked by stenciling or decals as follows 'MODIFIED--NOT FOR OPERATIONAL USE'. All rejected, non-operable parts and those modified parts which could not by means of depot-level overhaul be returned to RFI condition for operational use on the related end item shall be individually and permanently marked by stamping or engraving 'REJECTED--NOT FOR OPERATIONAL USE'. Where the size of part renders marking impractical or ineffective, the next higher assembly in which the part is used shall be so marked. Such marking will not be required on obviously cutaway parts."

The following wording on modified parts is also suggested:

> "Where modification of parts, subassemblies, assemblies, or units of ground, air, or space vehicles, or equipments is reflected in the applicable training equipment drawings, the pertinent drawing number shall also be marked on the next assembly drawing and stamped on the unit."

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.5 SAFETY MARKINGS.

"The safety marking requirements shall be as follows: _____
____
____."

Rationale and Guidance: When there are hazards associated with the trainer, warning signs should be required.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.20 specifies the following:

> "All safety hazards shall be provided with adequate and conspicuous warning signs. Signs ... shall display the words STAND CLEAR in 1/2-inch-high white letters on red translucent material. Trainers generating electromagnetic radiation shall have the minimum safe distances identified and marked."

Paragraph 3.3.6.1 of MIL-T-81821, specifies the following:

> "A back-lighted warning sign shall be centrally located on each of the four sides of all trainers used to demonstrate the operation of fast-acting mechanisms such as landing gear, flight controls, control surfaces, and speed brakes. The warning sign shall be illuminated any time the power source is turned on at the trainer. The warning lamp shall be enclosed in a metal box, the front surface of which shall be of a red translucent material not less than two (2) by three and one-half (3 1/2) inches ... ."

Background and Sources: Sources are referenced above.

Lessons Learned:

3.3.3.6 ELECTRICAL POWER MARKINGS.

"The electrical power marking requirements shall be as follows: ____
____."

Rationale and Guidance: To avoid misuse of the trainer in terms of power, the electrical requirements of the trainer should be clearly marked on the trainer.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.13 specifies the following:

"The electrical power required to operate each trainer, independently operable trainer panel, panel group and related trainer powered support equipment under specific load conditions shall be permanently marked on a plate similar to the manufacturer's data plate. The plate shall be permanently attached adjacent to the master keyed-lock switch and shall indicate the following as applicable:

Power Requirements			Amperage		
Voltage	Frequency	Phase	Standby	Start	Operate
28V	DC		*	*	*
120V	60 Hz		*	*	*
120V	400 Hz	Single	*	*	*
120/208V	400 Hz	Three			
		A	*	*	*
		B	*	*	*
		C	*	*	*

* Applicable data shall be entered."

<u>Performance Parameters</u>: A source is referenced in the discussion above.

<u>Lessons Learned</u>:

3.3.3.7 SHIPPING AND STORAGE MARKINGS.

"Shipping and storage marking requirements shall be:

____
____."

<u>Rationale and Guidance</u>: If the trainer is to be shipped or put into storage, then appropriate markings need to appear on the trainer.

<u>Performance Parameters</u>: MIL-T-81821, paragraph 3.3.3.23 specifies the following:

"All trainer equipment shall be marked for shipment and storage in accordance with MIL-STD-129."

However, before blanket reference is given, the engineer should review MIL-STD-129 and select the appropriate paragraphs or at least specify any acceptable exemptions.

Background and Sources: A source is identified in the discussion above.

Lessons Learned:

3.3.3.8 OTHER MARKINGS.

"____
____."

Rationale and Guidance: Subparagraphs 3.3.3.1 to 3.3.3.7 of the Prime Item Development Specification provide an opportunity to specify marking requirements which are typical. However, other markings may be required; e.g.,

- Center-of-Balance Marking(s).
- Electric Motor Marking(s).
- Hoisting Instruction Marking(s).
- Marking of Fluid/Gaseous Transmission Lines.
- Marking of Identification Plates for Sectionalized Components.
- Power Switch Warning Plate Marking(s).
- Fluid Tank or Reservoir Marking(s).

Each of these is discussed below:

Performance Parameters:

Center-of-Balance Marking(s): MIL-T-81821, paragraph 3.3.3.8, offers the following:

> "A vertical red arrow, approximately 2 by 6 inches, shall be stenciled on both longer sides of the trainer frame and outer cover, near the bottom edge, to indicate the point of balance of the trainer for forklifting. At the. top of the arrow, in red letters not less than 1 inch high, shall appear the legend CENTER OF BALANCE. If space is not available on the trainer frame for the 2- by 6-inch arrow, a red triangle or dot will be sufficient."

Electric Motor Marking(s): MIL-T-81821, paragraph 3.3.3.11 specifies the following:

> "All trainer peculiar unidirectional electric motors shall be marked to indicate the direction of rotation."

Hoisting Instruction Marking(s): MIL-T-81821, paragraph 3.3.3.19, specifies:

> "Hoisting instructions for lifting a heavy trainer shall be stenciled on the cover, including lifting points, need for spreader bar, and area for forklifting. A heavy trainer shall be defined as having a weight exceeding the one-man lift values of Table X in paragraph 5.9.11.3.2 of MIL-STD-1472."

Marking of Fluid/Gaseous Transmission Line(s): MIL-T-81821, paragraph 3.3.3.12, suggests the following wording:

> "All fluid/gaseous transmission lines and tubing shall be marked in accordance with MIL-STD-1247 with standard decals to indicate direction of flow, and shall bear the appropriate color-code tape."

Marking of Identification Plates for Sectionalized Components: MIL-T-81821, paragraph 3.3.3.14, specifies:

> "Where the manufacturer's identification plate has been removed due to the sectionalization requirements, the plate shall be attached to that portion of the item that is mounted on the trainer, if possible. Otherwise, the identification plate shall be attached to the component mounting plate."

Power Switch Warning Plate Marking(s): MIL-T-81821, paragraph 3.3.3.15 specifies the following:

> "A warning plate indicating 'WARNING--PLACE MASTER KEYED-LOCK SWITCH IN OFF POSITION BEFORE CONNECTING OR DISCONNECTING EXTERNAL POWER' shall be attached to the plug end of each trainer power cable. Another warning plate with the same legend shall be placed near the master keyed-lock switch."

NOTE: If a master keyed-lock switch is not used, then the above wording can be used with substitution of "Power Control" for "Master Keyed-Lock Switch."

Fluid Tank or Reservoir Markings: MIL-T-81821, paragraph 3.3.3.16 suggests the following:

> "The liquid capacity contents, and the words 'MUST BE DRAINED PRIOR TO SHIPMENT' shall be stenciled on any trainer fluid storage tank or reservoir."

NOTE: Emergency Power Switch marking can be presented either in this subparagraph or within some subparagraph of 3.3.6.5 of this specification. For convenience, the following wording is offered:

> "All emergency OFF switches shall consist of red push-buttons not less than 1.0 inch in diameter, recessed in black (FED-STD-595, Color 17038) and orange-yellow (FED-STD-595, Color 13538) diagonally striped panels, 2 inches or larger on a side. The width ratio of orange-yellow to black shall be three to one. The black stripe shall be in one of three widths: 1/16, 1/8, or 1/4 inch. The switch button shall not be integrally illuminated. Alternative lighting designs may be used that meet the requirement that the brightness contrast be sufficient to make the control identifiable under all projected illumination conditions. The control characteristics shall fall in the area labeled 'clear seeing' of sub note 3(1) DN2B2, DH 1-3. The nomenclature EMERGENCY OFF' shall be placed on each panel, consistent with the remainder of the panel nomenclature."

Background and Sources: Sources are identified in the discussion above.

Lessons Learned:

3.3.4 WORKMANSHIP.

> "The trainer shall meet the workmanship requirements specified below: ______________________________
> ____."

Rationale and Guidance: A list of specific requirements is offered below, in the Performance Parameters section of this subparagraph. However, it should be pointed out that other subparagraphs of the Prime Item Development Specification discuss present workmanship requirements. Thus, the engineer should be careful not to duplicate such requirements within this subparagraph.

Performance Parameters: Consider the following statement: "Workmanship shall be in accordance with Requirement 9 of MIL-STD-454."

Other areas to consider are:

- Welding; e.g., "All welding shall be accomplished in accordance with MIL-W-8604 and MIL-W-8611, as applicable."

- Hardware Installation; e.g., "The installation of hardware parts, such as hinges, catches, handles, or knobs shall be accomplished in such a manner as to avoid damaging the hardware or the mounting surface."

- Threaded Parts; e.g., "Screws, nuts, and bolts shall show no evidence of cross-threading, mutilation, or detrimental or hazardous burrs."

- Wiring; many of these may have been presented in subparagraph 3.3.1.6.9.1 of the Prime Item Development Specification, but are included here for completeness (and to allow the engineer some flexibility in completing the text for this subparagraph):

  (1) Wire dress or cabling of wires shall not interfere with mechanical operation which could lead to subsequent damage of the wire or cable.

  (2) Wires and cables subject to flexing shall be protected to prevent abrasion.

  (3) There shall be no evidence of burns, abrasions or punch marks in the insulation that could cause short circuits or leakage.

  (4) Wires in continuous run between two terminals shall not be spliced during the assembly of the equipment, except where a strand conductor is spliced to a solid conductor and the two are supported at the splice.

  (5) The clearance between wires or cables and heat-generating parts shall be such as to avoid deterioration of the wires on cables from the heat dissipated by these parts under the specified service conditions of the equipment.

  (6) Shielding on wires and cables shall be secured in a manner that will prevent it from contacting or shorting exposed current-carrying parts. The ends of the shielding or braid shall be secured against fraying.

- Screw Assemblies; e.g., "Assembly screws and bolts shall be torqued to the proper design values, without over-tightening, based on their dimensions, material, and type of application, and shall be of a single-thread type for each size used."

- Plug-in Modules; e.g., "Mating male and female plug-in modules shall be provided with positive keying safety arrangement to preclude insertion of a module into the wrong receptacle."

Background and Sources: Sources are identified in the discussion above.

Lessons Learned:

3.3.5 INTERCHANGEABILITY.

"The interchangeability requirements shall be as follows:

____
____."

Rationale and Guidance: A review of past specifications and military standards suggests three types of interchangeability should be considered in this subparagraph. The three types are: Physical Interchangeability, Structural Interchangeability, and Functional Interchangeability. Each of these is discussed below.

Performance Parameters: Interchangeability requirements can be found in Requirement 7 of MIL-STD-454 and MIL-STD-100; MIL-T-81821, paragraph 3.3.5 suggests that the requirements of MIL-I-8500 apply. Specification No. 16PS028A, paragraphs 3.3.5.1, 3.3.5.2, and 3.3.5.3, respectively, offer the following:

> "Physical Interchangeability . Parts shall require only the removal of attaching means (bolts, nuts, screws, pins, etc.) in order to make replacement. Parts shall be capable of being replaced, one by the other, without harm, misalignment, or injury to adjoining parts or structure. Fabricating operations such as cutting, filing, drilling, reaming, hammering, bending, prying, or forcing shall not be required.
>
> Structural Interchangeability. When used interchangeably, the parts must not reduce the structural strength below the required value.

> <u>Functional Interchangeability</u>. When used interchangeably, the parts must fulfill the same functional purpose and design value, and not require circuit alignment and adjustment procedures beyond organizational-level maintenance capabilities."

Furthermore, the following wording is suggested:

> "Where components conforming to the part selection requirements specified herein are available in assorted dimensions and tolerances, provisions shall be made to accommodate the larger sizes as maintenance action replacements. Similarly, where stock-listed items such as transistors, resistors, and capacitors of the same nominal performance characteristics with differing tolerances are available, the circuit design shall be designed to accommodate the widest tolerance for purpose of full maintenance."

<u>Background and Sources</u>: Sources are identified in the discussion above.

<u>Lessons Learned</u>:

3.3.6 SAFETY, GENERAL.

"a. The design and construction of the maintenance trainer shall consider optimum safety of personnel when installing, operating, adjusting, maintaining, and moving the maintenance trainer, either during operation or non-operation. The training device shall conform to the health and safety requirements of Requirement 1 of MIL-STD-454 and MIL-STD-1472, unless otherwise specified directly below. Procedures described in MIL-STD-882 shall be used to minimize potential hazards and to reduce the possibility of system degradation and personnel injury, unless otherwise specified directly below."

"b. The Military Standards referenced above shall apply, except as stated below: ____________________ ____."

<u>Rationale and Guidance</u>: Item <u>a</u> of subparagraph 3.3.6 of the Prime Item Development Specification provides blanket reference to the following Military Standards: Requirement 1 of

MIL-STD-454, MIL-STD-1472 and MIL-STD-882. Item b allows the preparer to specify any exceptions to these blanket references; e.g., one reviewed specification stated that an exemption should be granted for the "edge-rounding requirement" of MIL-STD-1472. Other exemptions should be entered as identified by the preparer, after reviewing the specified or referenced standards.

Instead of referencing MIL-STD-882, the following statement can be made:

> "The safety design of the training device shall be derived through the safety analysis and safety design reviews of the safety program required in the contract."

If this wording is preferred, then the last sentence in item a should be deleted and the above sentence added.

Performance Parameters: Review the Military Standards referenced in item a and enter any exemptions in item b.

Background and Sources: Sources are MIL-STD-882, Requirement 1 of MIL-STD-454, and MIL-STD-1472.

Lessons Learned:

3.3.6.1 HAZARDOUS MATERIAL.

"a. Materials used in the construction of the maintenance trainer shall not support the propagation of flame; all pyrotechnics (missile warheads, propellants) shall be inert."

"b. Where the generation of toxic or noxious gases cannot be eliminated, the design effort shall be toward the control and minimization of these hazards."

3.3.6.2 FIRE DETECTION.

"The fire detection requirements shall be as follows:

____

____."

Rationale and Guidance: There are two approaches that can be taken concerning fire detection. First, the maintenance trainer itself can contain detectors; i.e, the detectors can be built-in. The second approach is to rely on any fire detection system that the facility might have. This latter approach will not protect the equipment or facility as well as a built-in detection system; i.e., early detection is achieved by having the built-in system. In making the decision of which approach to use, the preparer should consider the following factors:

- The detection system of the facility (if the facility has been identified).

- The complexity and nature of the equipment (e.g., if the trainer is likely to burn quickly, then a built-in detection system should be used - this increases the likelihood of minimizing damage and injury).

If it is decided to rely on the facility detection system, this subparagraph can be deleted.

Performance Parameters: The following assumes the fire detection system is to be built-in:

> "The design shall include a complete fire, smoke detection, and alarm system which operates from facility power. Detectors shall be located in all appropriate contractor-furnished equipment, such as computer cabinets, student station(s), and instructor station(s). If the maintenance trainer requires the student to be in an enclosure (e.g., an enclosed simulated cockpit), then a heat sensor wire shall be installed in the interconnecting cable(s). Means shall be provided to rapidly locate any fire or smoke which is detected. The detection and alarm cables shall be separated from electrical power cables. Detectors shall be installed in accordance with NFPA Standard 72E. The guidance of DN 5D2 of AFSC DH 1-6 shall apply."

Background and Sources: See AFHRL-TP-84-49, paragraph 2.2.2.14, for a discussion of logistics factors associated with fire control.

Lesson Learned:

3.3.6.2.1 FIRE ALARM.

"The fire alarm requirements shall be as follows:

____
____."

Rationale and Guidance: This subparagraph should be completed only if subparagraph 3.3.6.2 was completed; i.e., this subparagraph does not apply if the detection system is not built-in.

Performance Parameters: Consider the following wording:

"There shall be a system to alert all personnel throughout the training device complex that fire or smoke detection has occurred. The specific aural or visual alarm means and locations to be provided shall be determined through safety analysis, and subject to approval by the procuring activity at the mockup/PDR. Care shall be exercised to ensure that the specific means provided do not present confusing information when compared with stimuli from other alerting devices such as the facility fire alarm, or the alarms simulated in the cockpit maintenance trainer, such as for a system malfunction."

Background and Sources: None.

Lessons Learned:

3.3.6.2.2 FACILITY FIRE CONTROL INTERFACE.

"Facility fire control interface requirements shall be as follows: ______________________________
____."

Rationale and Guidance: This subparagraph should not be completed if any of the following three circumstances prevail:

- Subparagraphs 3.3.6.2 and 3.3.6.2.1 were not completed (i.e., a built-in protection system is not a requirement).
- If the maintenance trainer is mobile and facility fire control interface is impossible or impractical.
- If there is no facility fire control system.

Performance Parameters: Consider the following wording:

"Interconnections with the facility fire control system shall be provided. Simulator smoke detection signals shall be provided to the facility fire control panel to provide a signal to activate the facility fire warning system in the appropriate facility fire zone where the simulator equipment is located. The simulator emergency power-off shall be capable of being activated by a signal from the facility fire control panel originating from activation of a facility fire/smoke detector or sprinkler system."

Background and Sources: None.

Lessons Learned: It should be noted that activation of a water sprinkler system may cause damage to the maintenance trainer. The purpose of the activation of the sprinkler is not to "save" the maintenance trainer but to save the facility.

3.3.6.3 OVERHEAT SENSING.

"The overheat sensing requirements shall be as follows:
____
____."

Rationale and Guidance: This subparagraph should be completed only if a cooling system is a requirement.

Performance Parameters: The following wording was adapted from MIL-T-81821, paragraph 3.3.6.2:

"Each major component, such as the instructor station, student station, and the computer cabinet, which is provided with a cooling system shall automatically deactivate power to the affected component in the event of a cooling system failure. Each component shall have its own warning system so that the specific component on which the failure has occurred can be identified."

Background and Sources: A source is referenced in the discussion above. Also see AFHRL-TP-84-49, paragraph 2.2.2.14, for a discussion of logistics factors associated with overheat detection.

Lessons Learned: Warning lights are typically used for this purpose.

3.3.6.4 FIRE STOP SEALING.

"____

____."

Rationale and Guidance: Fire seals are typically used when the trainer is picking up power (either electrical or hydraulic) from the facility.

If a false floor is going to be used for the computer equipment, then provisions must be made for controlling fire; however, this is usually not the responsibility of the contractor.

Performance Parameters: Consider the following wording:

> "Means shall be provided to seal facility-provided fire stops whenever training device cable runs are installed through the fire stop."

Background and Sources: See AFHRL-TP-84-49 for a discussion of logistics factors associated with fire control.

Lessons Learned:

3.3.6.5 EMERGENCY POWER-OFF.

"a. The emergency power-off requirements shall be as follows: ________________________________

____."

"b. The emergency power-off switch shall: ____________

____."

Rationale and Guidance (Item a): Emergency power-off should occur automatically in the following situations:

- When fire and/or smoke have been detected.
- When fast-acting mechanical parts have trapped limbs of the user (if such an event can be "sensed" on the training equipment).

In addition, emergency power-off should be activated by personnel observing a personal injury, via an emergency power-off switch. The switch is to be described in item b of this subparagraph.

Both the automatic and manually activated power-off control should be viewed as a personnel safety feature and not as an equipment salvation feature (i.e., emergency power-off is activated to save personnel and not equipment). Note an emergency power-off should not require an orderly shutdown (e.g., a shutdown that saves memory or core registers); the prime objective is safety of personnel.

Performance Parameters (Item a): When establishing the performance criteria, consideration should be given to the following:

- Location of emergency power-off switches.
- When automatic activation is required (e.g., detection of fire and/or smoke).
- What occurs during activation (e.g., should utility power be turned off, should emergency lighting be turned on).

Consider the following wording:

> "Emergency power-off control shall be provided at multiple locations throughout the training complex and shall be fail-safe. The number and location of these controls shall be subject to procuring activity approval at the mockup/PDR. Emergency power-off shall also occur automatically when the fire/smoke detection system is activated. When emergency power-off is initiated, all power to the training equipment, including utility power, shall be automatically removed. If the trainer involves an enclosure in which the student might be confined or located, then upon activation of the emergency power-off control the enclosure shall return to an egress position and any egress ramps or stairways shall also return to an egress position. In addition, emergency lighting shall be activated on all enclosed areas as well as on all possible escape routes. Furthermore, provisions shall be made to close all ventilation/air-conditioning dampers automatically. Alternate escape provisions shall be provided and be subject to approval by the procuring activity."

Background and Sources (Item a): None.

Lessons Learned (Item a):

"b. The emergency power-off switch shall: ____________
____
____."

Rationale and Guidance (Item b): As an alternative, the information requested here can be provided in subparagraph 3.3.3.8. However, for maximum flexibility the same phrasing is offered here.

Performance Parameters (Item b): Consider the following wording:

"All emergency OFF switches shall consist of red push-buttons not less than 1.0 inch in diameter, recessed in black (FED-STD-595, Color 17038) and orange-yellow (FED-STD-595, Color 13538) diagonally striped panels, 2 inches or larger on a side. The width ratio of orange-yellow to black shall be three to one. The black stripe shall be in one of three widths: 1/16, 1/8, or 1/4 inch. The switch button shall not be integrally illuminated. Alternative lighting designs may be used that meet the requirement that the brightness contrast is sufficient to make the control identifiable under all projected illumination conditions. The control characteristics shall fall in the area labeled 'clear seeing' of sub-note 3(1) DN2B2, DH 1-3. The nomenclature 'EMERGENCY OFF' shall be placed on each panel, consistent with the remainder of the panel nomenclature."

Background and Sources (Item b): None.

Lessons Learned (Item b):

3.3.6.6 OTHER SAFETY REQUIREMENTS.

"____
____."

Rationale and Guidance: Subparagraphs 3.3.6.1 through 3.3.6.5 specify specific safety requirements. This subparagraph is reserved for trainer-peculiar items, such as an emergency intercommunication system and an emergency lighting system.

Performance Parameters:

- Emergency Communication System. Such systems are typically not used on a maintenance trainer. However, if the

trainer is designed such that enclosures are required or that part of the trainer is in a different room, then an emergency communication system might be required. When identifying the system, indicate:

- Locations of intercommunication devices.
- Activation procedures (when activated).
- Frequency range.
- Signal strength, etc.

. Emergency Lighting System. Typically, emergency lighting is used if the trainer is designed as an enclosure. Consider the following wording:

> "When required by facility lighting, low-intensity guarded lights shall be provided to illuminate the walkway, stairways, ramps, and enclosures. Where necessary, enclosure interior emergency lighting shall be provided and be activated automatically upon loss of facility power. When used, emergency lighting batteries shall be:
>
> - Rechargeable.
> - Leakproof, spill-proof.
> - Low maintenance.
> - Long life."

Background and Sources: None.

Lessons Learned: Often the engineer cannot perceive all possible hazards and their control. The following general statement is suggested:

> "In the event that one or more design features of this specification ... constitute a hazard to personnel using or maintaining the training equipment, notification of this condition shall be made to the procuring activity for direction. This notification shall include recommendations for appropriate revisions to remove the hazard."

The above wording would be appropriate to use in completing this subparagraph.

3.3.6.7 ACOUSTIC NOISE.

3.3.6.7.1 HAZARDOUS NOISE.

"a. The sound level and exposure time in all areas where the instructor or student might be working shall be held below the values calculated from the following formula:

$$T \triangleq 16 \div 2^{(L-80)/4}$$

where T = Duration of Total Daily Exposure (in hours).
L = Noise Level in dBA."

"b. The maximum dBA shall be: ____."

Rationale and Guidance: Item a sets sound level and exposure time criteria. Typically this has been set using a table; e.g., "Threshold Limit Values for Non-Impulsive Noise" (American Conference of Governmental Industrial Hygienists). The formula offered in item a is an approximation of these tables. A problem emerges in using this formula, which should be carefully thought out. It provides a daily exposure at a specific dBA. Typically the contractor or vendor will determine the dBA of the maintenance trainer and then provide the duration time. However, this time may not be practical in terms of the training; e.g., a 15- minute exposure of 115 dBA may not be a sufficient time to accomplish the training. If time and noise level are a problem, then this subparagraph should specify the time of the training at some predictive dBA or range of dBAs; e.g., "The trainer shall be designed to permit a ___-hour exposure at a maximum of ____ dBA." To complete the blanks in the above sentence, the engineer must use a table directly.

Secondly, the provided formula does not allow the calculation of an exposure time if there are two or more noise levels (simultaneously) from two or more sources. (NOTE: A rough approximation can be obtained by adding the two dBAs as logs and by substituting this combined value in the formula for L.) However, a more accurate approximation can be obtained using a standard table and adding (directly and not as logs) the obtained values.

Item b is provided only to assure that a maximum recommended dBA is not exceeded. The maximum recommended dBA is given in the next paragraph.

Performance Parameters: Currently the maximum recommended value is 115 dBA.

Background and Sources: The 115 dBA maximum originates from Occupational Safety and Health Administration (OSHA) literature and AFR 161-35. 115 dBA can be exceeded, providing ear protection is provided, but ear protection may not be appropriate if the maintenance trainer is used as a demonstration device. See AFHRL-TP-84-49, paragraph 2.4.2.9, for a discussion of noise levels and other potential training interference factors.

Lessons Learned: It seems appropriate to suggest that training cannot be conducted at the maximum recommended dBA. Trainers should be designed to allow speech to be heard (see paragraph 3.3.6.7.2 of this specification).

3.3.6.7.2 SPEECH INTERFERENCE NOISE LEVEL.

"a. The noise level at student and instructor stations shall not exceed an articulation index (AI) of 0.7, where the AI is determined by the Octave Band Method."

"b. Exception: Where simulated sounds reflecting actual aircraft conditions for the student(s) violate the AI above, the requirements of this paragraph are void for the time period that such simulated sounds are actuated, except that the limits in paragraph 3.3.6.7.1 herein shall not be exceeded."

NOTE: This subparagraph guarantees that students will be able to hear the instructor during a demonstration, while the maintenance trainer is operating.

3.3.6.8 SAFETY DESIGN.

"The safety design requirements shall be as follows: ____."

Rationale and Guidance: This subparagraph provides an opportunity for the preparer to specify any special design requirements.

Performance Parameters: The following design notes (DN) of AFSC D 1-6 may apply:

- DN 2C2, Man-Machine Safety Design Requirement.
- DN 2E1, 2, and 3, Introduction, Procedures, and Selection of Safety Analyses.
- DN 2E4, Resolution of Safety Hazards.

- DN 4A2, Material Handling Equipment.

- DN5D2, Fire Detection.

- DN 6A1-7, Environmental Parameters of Man.

- DN 4A1-2, Electrical/Electronic Equipment.

- DN 4C1-3, Hydraulic Equipment.

Background and Sources: Sources are identified in the above discussion.

Lessons Learned:

3.3.7 HUMAN PERFORMANCE/HUMAN ENGINEERING.

> "In order to achieve optimum performance of the instructor, student, and maintenance personnel, and to assure a high degree of man-machine compatibility, the trainer shall: ____ ____."

Rationale and Guidance: It is essential that the trainer be designed considering human factors interactions. There are many military standards and specifications which deal with human engineering.

Performance Parameters: MIL-T-81821, paragraph 3.3.7, suggests that the criteria of MIL-STD-1472 be applied. Other reviewed documents suggest that the requirements of MIL-H-46855 should be applied, and that paragraphs 5.10, 5.11, and 5.12 of MIL-STD-1472 should not be applied. The Human Engineering Guide to Equipment Design can be recommended to provide additional design guidance for work space layout, consoles, controls, and displays.

The preparer should review the documents listed above and specify any exemptions.

Background and Sources: Sources are identified in the discussion above. Also see AFHRL-TP-84-49, paragraph 2.4.2.4, for a discussion of some logistics concerns associated with human engineering design.

Lessons Learned:

3.4 DOCUMENTATION

> "Documentation shall be provided as specified in this specification and on the Contract Data Requirement List (CDRL)."

Rationale and Guidance: Documentation is an important aspect of maintenance trainer development, use, operation, and maintenance. Typically, documentation is provided through Data Item Descriptions (DIDs) (DD Forms 1664) cited on the DD Form 1423, Contract Data Requirement List (CDRL) section of the contract.

MIL-STD-490 (paragraphs 20.3.4, page 36) specifies, "This paragraph shall specify the plan for item documentation such as: specifications, drawings, technical manuals, test plans and procedures, installation instruction data." Although the typical plan is to provide DIDs in the contract, you should be familiar with the usual DIDs contained in maintenance trainer development contracts. A list of useful DIDs is provided in the Performance Parameters section of this paragraph (see below). In addition to specifying documentation requirements in the contract, it should be noted that this specification can also contain documentation requirements; e.g., the paragraphs and subparagraphs of this specification allude to the need for having software documentation, instructor user guides, etc. Although no blanks have to be completed in the paragraph, it is encouraged that the specification preparer become familiar with the typically used DIDs.

Performance Parameters: MIL-T-81821 (pages 43 to 52) provides a list of DIDs that should be reviewed before constructing the Contract Data Requirements List (CDRL) section of the contract. In addition, MIL-STD-1379B (Contract Training Programs) Appendices A and B should also be carefully reviewed. MIL-STD-1379B, Appendix B contains actual DD Form 1664s. The DIDs referenced in MIL-T-81821 and MIL-STD-1379B are listed below. Also in the list below are DIDs that have appeared in recent maintenance trainer contracts. For your current specific application, the DIDs listed below may have to modified.

Not all the data item descriptions needed for a particular application are listed; i.e., the list is not meant to be exhaustive.

DID NO.	TITLE	SOURCE OR REFERENCE
DI-A-3009	Program Milestones (Acquisition Phase)	Contracts (AFSCM 174-1)
DI-A-3029	Agenda - Reviews, Configuration Audits, and Demonstrations	Contracts MIL-STD-1521A)
DI-A-5239B	Management Plans "Update Only"	Contracts (DODI 7000-2)
DI-A-6100A	Report, Make or Buy Analysis, Maintenance Training Equipment	MIL-T-81821 (1) (Paragraph 3.4.-7.6)
DI-A-6103A	Report, Material Requirements/Receipt, Maintenance Training Equipment	MIL-T-81821 (1) (Paragraph 3.4.-7.4)
DI-E-3102A	Configuration Item Development Specification	Contracts (MIL-STD-490)
DI-E-3103A	Configuration Item Product Fabrication Specification (Note: Usually not required for maintenance trainers)	Contracts (MIL-STD-490)
DI-E-3106	Specifications Maintenance Document (Equipment/Munitions)	Contracts (MIL-STD-483)
DI-E-3108	Configuration Management Plan	Contracts
DI-E-3118	Minutes of Formal Reviews, Inspections, and Audits	Contracts (MIL-STD-1521A)
DI-E-3119	Computer Programs Development Specification	Contracts
DI-E-3120	Computer-Programs Product Specification	Contracts

Table 1. Sample DID List.

DID NO.	TITLE	SOURCE OR REFERENCE
DI-E-3121	Version Description Document (Computer Program)	Contracts (MIL-STD-483)
DI-E-3122	Configuration Index (Computer Program)	Contracts (MIL-STD-483)
DI-E-3123	Change Status Report (Computer Program)	Contracts (MIL-STD-483)
DI-E-3126A	Request for Nomenclature	Contracts (MIL-STD-875A)
DI-E-3127A	Advance Change Study Notice (ACSN)	Contracts (MIL-STD-483)
DI-E-3128	Engineering Change Proposals (ECPs)	Contracts (MIL-STD-490)
DI-E-3129	Requests for Deviation/Waiver	Contracts (MIL-STD-480)
DI-E-3133	Configuration Management Accounting Reports (Machine or Manually Prepared)	Contracts (MIL-STD-482A)
DI-E-3134	Specification Change Notice (Computer Program)	Contracts (MIL-STD-490)
DI-E-3162B	Computer Program Identification Number/ Air Force Computer Resource Inventory Data	Contracts (MIL-STD-483)
DI-E-7027	Program Parts Selection List	Contracts
DI-E-7031	Drawings, Engineering, and Associated Lists	Contracts (DOD-D-1000 B[1])

Table 1. Sample DID List. (Continued)

DID NO.	TITLE	SOURCE OR REFERENCE
DI-E-30142	Master Engineering Document Lists	Contracts (MIL-STD-100B[2])
DI-F-6000C	Cost Performance Report (CPR)	Contracts (DODI 7000.10)
DI-F-6004B	Contract Funds Status Report (CFSR)	Contracts (DODI-7000.10)
DI-F-6006	Cost Data Summary Report (DD Form 1921)	Contracts (DODI 7000.11)
DI-F-6007	Functional Cost Hour Report (DD Form 1921-1)	Contracts (DODI 7000.11)
DI-F-6008	Progress Curve Report (DD Form 1921-2)	Contracts (DODI 7000.1)
DI-F-6009	Plant-Wide Data Report (DD Form 1921-3)	Contracts (DODI 7000.1)
DI-F-6010A	Cost/Schedule Status Report (C/SSR)	Contracts (DODI 7000.1)
DI-H-2028A	The Instructor Utilization Handbook	Contracts
DI-H-3256	Training Equipment List	Contracts
DI-H-3258A	Training Support Data	Contracts (AFR 8-2 [1])
DI-H-3277	Training Equipment Computer Program Documentation	Contracts

Table 1. Sample DID List. (Continued)

DID NO.	TITLE	SOURCE OR REFERENCE
DI-H-6133A	Manuals, Photographic, Maintenance Training Equipment	MIL-T-81821(1) (Paragraph 3.4.6)
DI-H-6134A	Reports, Engineering and Production Progress, Maintenance Training Equipment	MIL-T-81821(1)
DI-H-6135A	Reports, Facilities - Maintenance Training Equipment	MIL-T-81821(1)
DI-H-7047	System Safety Program Plan	Contracts
DI-H-7048	System Safety Hazard Analysis	Contracts
DI-H-7049	Safety Assessment Report	Contracts
DI-H-7050	System Safety Engineering Report	Contracts
DI-H-7066	Training and Training Equipment Plan	MIL-STD-1379B (Paragraph 5.5.1, page 15)
DI-H-7067	Training Course Proposal	MIL-STD-1379B (Paragraph 5.5.2, page 15)
DI-H-7068	Task and Skill Analysis Report	MIL-STD-1379B (Paragraph 5.5.3, page 15)
DI-H-7069	Training Course/Curriculum Outlines	MIL-T-81821 (Paragraph 3.4.4) and MIL-T-1379B (Paragraph 5.5.4, page 17)

Table 1. Sample DID List. (Continued)

DID NO.	TITLE	SOURCE OR REFERENCE
DI-H-7070 (Supersedes DI-H-6198)	Instructor/Lesson Guides--Training Courses	MIL-T-81821 (Paragraph 3.4.4) and MIL-STD-1379B (Paragraph 5.5.5, page 17)
DI-H-7071 (Supersedes DI-H-6199)	Student's Training Course Guide	MIL-T-81821 (Paragraph 3.4.4) and MIL-T-1379B (Paragraph 5.5.6, page 18)
DI-H-7072 (Supersedes DI-H-6124)	Audiovisual Aids, Master Reproducibles and Review Copies for Training Equipment and Training Courses	MIL-T-81821 (Paragraph 3.4.11) and MIL-T-1379B (Paragraph 5.5.7, Page 18)
DI-H-7073 (Supersedes DI-H-6123)	Audiovisual Aids Index for Training Equipment and Training Courses	MIL-T-81821 (Paragraph 3.4.9.15) and MIL-T-1379B (Paragraph 5.5.8, page 18)
DI-H-7074	Tests for Measurement of Student Achievement	MIL-STD-1379B (Paragraph 5.5.9, page 18)
DI-H-7075	Student and Training Course Evaluation Forms	MIL-STD-1379B (Paragraphs 5.5.10, page 18)

Table 1. Sample DID List. (Continued)

DID NO.	TITLE	SOURCE OR REFERENCE
DI-H-7076	Instructor's Utilization Handbook for Simulation Equipment	MIL-STD-1379B (Paragraph 5.5.11, page 19)
DI-H-7077	On-the-Job Training Handbook	MIL-STD-1379B (Paragraph 5.5.12, page 19)
DI-H-7078	Technical Hands-On Training System Packets	MIL-STD-1379B (Paragraph 5.5.15, page 20)
DI-L-3333A	Decalcomanias and Other Marking	Contracts (MIL-STD-130E)
DI-L-6138	Integrated Support Plan	Contracts
DI-L-6139A	Report, Rejected/Non-Operable Parts Utilization, Maintenance Training Equipment	MIL-T-81821(1) (Paragraph 3.4.7.7)
DI-M-3401	Technical Order Publications Plan	Contracts (AFLCM 400-4)
DI-M-3402	Technical Order Status and Schedules	Contracts (AFLCM 400-4)
DI-M-3405A	Technical Order CFAE/CFE Notices and Related Technical Orders	Contracts (MIL-N-7384C [1])
DI-M-3407B	Technical Orders	Contracts (MIL-M-87158)
DI-M-3408	Validation Record (Technical Orders)	Contracts (AFLCM 400-4)
DI-M-3409	Positional Handbook - Information System Operational Personnel	Contracts
DI-M-3410	Users Manual (Computer Program)	Contracts (AFSCM 375-7)

Table 1. Sample DID List. (Continued)

DID NO.	TITLE	SOURCE OR REFERENCE
DI-M-3411	Computer Programming Manual	Contracts (DOD 7935. 1-5)
DI-M-3418C	Aerospace Vehicle, Equipment Maintenance, Historical and Inventory Records	Contracts (MIL-W-25140B)
DI-M-6152A	Manuals, Operation and Maintenance Instructions, Maintenance Training Equipment	MIL-T-81821 (1) (Paragraph 3.4.2)
DI-M-6153	Technical Manuals/Commercial Literature	Contracts (MIL-M-7298C [2])
DI-P-3453	Special Tooling and Special Test Equipment (ST/STE)	Contracts
DI-P-3472A	Procurement Data Packages and Lists	Contracts (MIL-STD-789B)
DI-R-2174	Software Quality Assurance Program Plan	Contracts (DOD-STD-1679A)
DI-R-3530	Electromagnetic Compatibility Plan	Contracts (MIL-E-6051D [1])
DI-R-3547	Reliability and Maintability Report on Commercial Equipment	Contracts (MIL-STD-785A)
DI-R-3548B	Suspect Material Deficiency Notice (Alert) and Response	Contracts (MIL-STD-1556A)
DI-S-3596A	Support Equipment Recommendations Data (SERD)	Contracts (AFR 65-3)
DI-S-6169	Optimum Repair Level Analysis (ORLA) Report	Contracts (MIL-STD-1388-1)

Table 1. Sample DID List. (Continued)

DID NO.	TITLE	SOURCE OR REFERENCE
DI-S-6177B	Calibration/Measurement Requirements Summary (CMRS)	Contracts (AFR 74-2)
DI-S-30567A	Computer Program Development Plan (CPDP)	Contracts (AFR 800-14)
DI-T-3703A	Computer Program Configuration Item (CPCI) Test Plans/Procedures	Contracts (MIL-STD-483)
DI-T-3704B	Electromagnetic Capability Test Plan	Contracts (MIL-E-6051D [1])
DI-T-3714A	Acceptance Test Procedures	Contracts (MIL-STD-490)
DI-T-3717A	Computer Program Configuration Item (CPCI) Development Test and Evaluation Test Report	Contracts AFR 80-14)
DI-V-6181	Repair Parts/GSE Price List	Contracts
DI-V-6185A	Standard/Modified Hand Tools List	Contracts (MIL-STD-1388-1)
DI-V-7004	Long Lead Time Items List (LLTIL)	Contracts (MIL-STD-1561A)
UL-76-AQ	Report, Logistic Support Cost (LSC) Status	Contracts
UL-77A-MM	Integrated Logistics Data File	Contracts

Table 1. Sample DID List. (Continued)

Background and Sources: The DIDs listed above were obtained by reviewing MIL-T-81821, MIL-STD-1379B, and recent maintenance training procurement contracts. Current DIDs are listed in the AMSDL (D.D 5000.19-L, Vol. II). See AFHRL-TP-84-49 paragraphs 2.2.2.12, 2.2.2.13a, 2.2.2.13b, 2.4.2.3, 2.5.2.2, and 2.7.2.10 for information on logistics support factors associated with documentation.

Lessons Learned: The preparer of the specification should not automatically include all the DIDs listed above just because they were referenced in recent contracts or MIL-T-81821 and MIL-STD-1379B. The DIDs incorporated either into the specification or the contract should be carefully selected; i.e., selected to suit the needs of the current situation. The selection should be based on such issues as: Is the report or data item needed, who is going to use the data item, for what purpose is the data item going to be used, etc? Data items are deliverables and can significantly increase the cost of the contract; therefore, they must be selected carefully. It makes no sense to include a data item simply because it was used or requested in a previous contract, if that particular data item is not applicable to the current situation or will not be used in the current situation.

It is also important to have documentation for off-the-shelf devices; e.g., CRTs, line printers, processors. This documentation is needed to ensure the availability of sufficient user data to support the trainer. In some cases (in the past) user manuals did not contain sub-unit malfunction isolation and repair data; instead, the user was directed to commercial manuals. Often, however, the commercial manuals were not readily available or were not in a format usable by the Air Force personnel. The contractor or vendor should be aware that commercially available manuals may not be acceptable to the Air Force if they do not supply the requirements specified by the DIDs. If commercial manuals are not acceptable to the Air Force, then it should be understood that the trainer contractor or vendor has the responsibility to improve the commercial documents so that the DID requirement is satisfied. Thus, it is important, when specifying the DIDs, to make it clearly understood that such documentation, in a usable format, is required as deliverable items. It is also important to clearly specify the timely release of the documentation to the using command.

The problems associated with a lack of sufficient operation and maintenance manuals for the trainer can be illustrated with a few examples. It has been judged by the Air Force users that a current series of Organizational/Maintenance (O&M) manuals for a particular trainer does not contain

sufficient diagnostics to isolate the computer and/or peripheral devices to a line replaceable line item. The previously agreed-upon acquisition of off-the-shelf commercial manuals to supplement the O&M series has been proven to be highly undesirable. A series of legal ramifications have surfaced involving the release of proprietary data. While the need for proprietary data is essential for an in-depth repair at depot, it is not needed for field use when isolating the replaceable units.

One possible solution to this problem or situation is to include only that information needed to diagnose and isolate the replaceable unit or item in the field and include this information in the O&M series.

The non-release of any one commercial manual renders the trainer support mode ineffective. The only recourse for the operators/users of the above trainers is to place an Interim Contractor Support (ICS) call to troubleshoot, isolate, and repair the equipment. Obviously, the present situation requires an unneeded expenditure of USAF funds and/or a "shotgun" approach by the users to repair the trainer.

It has also been suggested from past experiences that software manuals be combined with instructor utilization manuals; i.e., the use of multiple documents to perform operation and maintenance is not desired. In order to specify that such manuals be combined, the preparer may find it necessary to modify some of the DIDs listed above.

It should also be mentioned that previous Contract Data Requirement Lists (CDRLs) invoked Data Item DI-M-3410, User's Manual (Computer Program), with the intent that this document would be sufficient for the users/operators to interface with the O&M series and conduct training exercises. No one stand-alone document exists for that training program to allow this particular function. The Computer Program Users Manual (common operational software) is an engineering document and contains the basic information to allow training preparation for the trainers, but does not stand alone to allow power-on and initialization, nor does it provide a scenario (chronologically sequenced) for the user/instructor. The existing manual was not designed for the user/instructor, but was designed as a document to enhance the Software Support Program (engineering). A "new" data item has been identified: DI-H-2028A/M Instructor's Utilization Handbook for Simulation Equipment. This handbook has been incorporated into the aforementioned system and is expected to resolve the problem. Systems now specifying this data item are: F-16 SAMT, F-15 SAMT, B-52 Offensive Avionics System (OAS), Maintenance Procedural Simulator (MPS), and E3A AWACS Advanced Radar System Maintenance Simulator.

3.5 LOGISTICS

3.5.1 MAINTENANCE CONCEPT.

"a. The maintenance concept of the proposed maintenance trainer shall be: ______________________________ ______________________________."

"b. The following personnel shall have the responsibility to update the trainer: ______________________________ ______________________________."

<u>Rationale and Guidance</u>: This subparagraph should contain a discussion of the following:

Use of multi-purpose test equipment.
Built-in test usage.
Use of modules vs. part replacement.
Maintenance and repair cycles.
Accessibility.
Level of repairability by the Government.

<u>Performance Parameters</u>: Specification No. 16PS028A, paragraph 3.5.1 (page 36) provides a reasonable example:

"Design of the trainer shall be consistent with the standard Air Force concept of three levels of maintenance. Organizational- and intermediate-level maintenance will be accomplished by Air Training Command (ATC). Accomplishment of depot-level maintenance shall be determined by Air Force Logistics Command (AFLC). In order to promote ATC maintenance self-sufficiency, design for depot repair shall be kept to the essential minimum consistent with life cycle cost. Source, maintenance and recoverability (SMR) codes, which determine maintenance repair policies, shall be assigned on the basis of the results of qualitative and quantitative logistic support analysis (LSA) tasks. Self-test and fault isolation (built-in-test) capabilities shall be incorporated in the design to the extent that those features are justified by life cycle cost and ATC self-sufficiency. The SAMT shall be designed for rapid and straightforward maintenance. Field replaceable components and assemblies shall be easily identified and readily accessible. Organizational and intermediate maintenance shall be accomplished by Field Training Department (FTD) instructor personnel using a minimum quantity of hand tools. Design of the SAMT shall emphasize modularity of components to the maximum extent to facilitate maintenance."

With little modification the above phrasing can be adapted to your specification application. Also note that specific reference can be given to other paragraphs within this specification (e.g., the type of built-in tests can be referenced in a specific subparagraph).

It has been mentioned throughout the Prime Item Development Specification and this Handbook that the trainer should be easily updated (i.e., kept current with the operational equipment). The updateability concept of the trainer should impact upon the maintenance concept. It makes sense to suggest that the updateability of the trainer be handled by organizational-level personnel. Thus in item b, the blank can be completed by entering "organizational-level personnel". If the current situation dictates that organizational-level personnel are not the best to update the trainer, then the most appropriate group should be entered. Often the responsibility for updating the trainer is dependent upon the nature of the update; e.g., if the update involves software changes, then perhaps one level of maintenance should handle it. If the change is a hardware change, then perhaps another level should have the responsibility. If such a division of labor is dictated, then the preparer should specify that division of labor in this subparagraph.

Background and Sources: Source is offered above. The content of this subparagraph conforms to the requirements of paragraph *20.3.5.1 of MIL-STD-490. See AFHRL-TP-84-49 paragraphs* 2.1.2.6 and 2.5.2.1 for a discussion of logistics factors related to the trainer maintenance concept.

Lessons Learned: Preventive and remedial maintenance are usually performed by the same organization, whether it is the school, another organization within the Air Force, the original manufacturer/vendor, or another private organization.

3.5.2 SUPPLY.

"Supply requirements shall be as follows: ________________
____."

Rationale and Guidance: It is critical that the design of the maintenance trainer consider the logistics required to support the trainer. It should be realized that the trainer must be supported while in the Air Force inventory, and that its support must be within Air Force assets and capabilities. There are really two concerns to be considered, one dealing with the hardware and one dealing with the software.

Performance Parameters: Insert the supply requirements in the blank provided. The following suggestion is offered:

"Supply requirements shall be as follows:

1. Selection of parts shall be in accordance with subparagraph 3.3.1.1 of this specification.

2. Computational system spare shall be in accordance with subparagraph 3.7.2.1.8."

Background and Sources: Typically, the information provided in this subparagraph is in accordance with other subparagraphs of the specification. See AFHRL-TP-84-49 paragraphs 2.4.2.1, 2.4.2.2, and 2.6.2.9 for a discussion of logistics factors associated with supply requirements.

Lessons Learned: It is essential that in the absence of Air Force support capabilities, contractor or vendor support in the form of interim support spares/repair parts packages and/or contractor or vendor support service be identified. Such requirements can be specified within this subparagraph.

In addition, logistics support priorities for production materials must be allocated priorities according to AFR 50-11 and incorporated into allocation and delivery schedules for the trainer, support equipment, and spare and repair parts.

Supply of the software is a configuration management concern. Before specifying software supply requirements, the preparer should consult with a computational system expert and configuration management personnel.

3.5.3 FACILITY AND FACILITY EQUIPMENT.

"The facility and facility equipment requirements shall be as follows:

____

____."

Rationale and Guidance: MIL-STD-490, subparagraph 20.3.5.5, page 36, states the following:

"This paragraph shall specify the impact of the item on existing facility and existing facility equipment. It also shall specify requirements for new facilities or ancillary equipment to support the item."

In the above quote, "item" refers to the trainer.

Typically, the contractor or vendor will only be responsible for the interface of the maintenance trainer with the facility and the facility equipment. Thus, this subparagraph should establish these interface requirements.

Performance Parameters: As stated above, typically, this subparagraph will state the interface requirements; i.e., the requirements the contractor or vendor must meet in interfacing the maintenance trainer with the existing facility and facility equipment. To specify these requirements, it should be realized that interface requirements are established in other parts (subparagraphs of the specification). For example, some interface requirements are stated in subparagraph 3.1.2, INTERFACE DEFINITIONS. Furthermore, utility power requirements are specified in subparagraph 3.3.1.6.5 and mechanical connector requirements are specified in subparagraph 3.3.1.7. Both of these subparagraphs may have implications for interface requirements.

Given that most, if not all, of the facility and facility equipment requirements are specified elsewhere in the specification, the following wording is suggested:

> "The facility and facility equipment requirements shall be as follows:
>
> 1. Interface of trainer with the facility and facility equipment shall be in accordance with: ________________ ____.
>
> 2. ____ ____."

In the first blank the preparer can insert the reference to paragraphs and subparagraphs of the Prime Item Development Specification; e.g., ". . . in accordance with subparagraphs 3.1.2, 3.3.1.6.5, and 3.3.1.7." Only those subparagraphs which establish interface requirements, however, should be included.

The second blank is reserved for specifying any requirements which were not already established within the specification.

Background and Sources: The preparer should see subparagraph 20.3.5.3 of MIL-STD-490 for guidance. For convenience, the information in that subparagraph of MIL-STD-490 is included in the Rationale and Guidance section of this subparagraph. The preparer should also see the following subparagraphs of this specification: 3.1.2, 3.3.1.6.5, and 3.3.1.7. For a discussion of logistical support considerations associated with facility operation, see AFHRL-TP-84-49, paragraph 2.4.2.7.

Lessons Learned:

3.6 PERSONNEL AND TRAINING.

3.6.1 PERSONNEL.

"The maintenance trainer shall be designed to be updated, maintained, and operated by: ______________________________
____."

Rationale and Guidance: The content of this subparagraph provides guidance to the contractor or vendor. This subparagraph shall specify the personnel requirements which the contractor or vendor must integrate into the maintenance trainer design. Two types of personnel must be considered - the instructors, who will operate the maintenance trainer, and maintenance personnel (including those people responsible for making software modifications and updates - e.g., update of data files). Often the instructor is given both responsibilities.

The best way to communicate the characteristics of the instructors to the contractor or vendor is to list the experience the instructors have had with maintenance trainers which are similar to the proposed maintenance trainer.

Maintenance personnel can be described by giving reference to the AFSC which will have responsibility for maintenance. If software is to be updated and maintained, and this requires a different AFSC, be sure to specify the AFSC and identify the maintenance/update tasks to be performed by that AFSC.

Performance Parameters: Enter instructor qualifications (if known).

It may be more difficult to specify the AFSC of the maintenance personnel since a design and LSA have not yet been prepared for the maintenance trainer; however, if possible, a target maintenance AFSC should be specified. This will provide guidance to the contractor or vendor. If it is only a target estimate, it should be so stated in this subparagraph.

Background and Sources: This is a modification of paragraph 20.3.6.1 of MIL-STD-490. MIL-STD-490 also requests that the characteristics of the student be specified in this subparagraph; however, student requirements have been specified in other subparagraphs of the Prime Item Development Specification. See AFHRL-TP-84-49 paragraphs 2.5.2.3 and 2.7.2.7 for a discussion of logistics factors associated with personnel.

Lessons Learned: Preventive and remedial maintenance are usually performed by the same organization, whether it is the school, another organization within the Air Force, the original manufacturer/vendor, or another private organization.

3.6.2 TRAINING.

"The training of personnel requirements shall be as follows:

____

____."

Rationale and Guidance: The contractor or vendor should design the maintenance trainer such that a minimum of training shall be required to gain proficiency in its operation, maintenance, and update by the personnel specified in subparagraph 3.6.1.

Often Type I training is required; however, this is typically handled under a separate contract.

Performance Parameters: Enter the intent to obtain training or specify that the trainer design shall be such that no training or a minimum amount of training shall be required.

Background and Sources: See paragraph 20.3.6.2 of MIL-STD-490. Also, see AFHRL-TP-84-49 paragraphs 2.3.2.2 and 2.7.2.7 for information on logistics factors associated with personnel training.

Lessons Learned: It is advisable to include a training package as part of the procurable items of the trainer acquisition. Be sure such a package is included in the CDRL.

3.7 MAJOR COMPONENT CHARACTERISTICS.

This major paragraph requires no input from the preparer. However, some explanation of the way the subparagraphs associated with this major paragraph are organized is needed.

In subparagraph 3.1.3, MAJOR COMPONENT LIST, the major components of the trainer are listed. For ease of understanding, this paragraph (paragraph 3.7) should parallel the organization of paragraph 3.1.3; i.e., each major component listed in subparagraph 3.1.3 should be presented in this paragraph. However, it should be noted that the malfunctions to be simulated and the degree of fidelity of the components to be represented on the trainer (student station) are specified in subparagraphs 3.2.1.3 and 3.2.1.4 (and its associated subparagraphs), respectively. As such, some parts of the major components may not have to be described in this paragraph (paragraph 3.7), since they are described elsewhere in the specification. This paragraph (paragraph 3.7) should be reserved for describing those major components and their parts which are not described elsewhere in this specification.

Although it is recommended that this paragraph parallel the organization of subparagraph 3.1.3, it should be noted that the subparagraphs of 3.7 are pre-organized in the specification. There are essentially three major subparagraphs: 3.7.1, 3.7.2, and 3.7.3. Subparagraph 3.7.1 presents the characteristics of the instructional system programs (instructional software). Subparagraph 3.7.2 presents the characteristics of the Computational Resources. (It should be noted that the Computational Resources include the Computer Program System, the software.) Thus, subparagraph 3.7.2 discusses not only the computational system equipment (computer), but also the software associated with the computational system equipment. It would be possible to subsume the information presented in 3.7.1 under subparagraph 3.7.2, since the instructional system programs can also be visualized as part of the computer program system. In fact, the instructional system programs are legitimately part of the Computational System since instructional system programs are also software. However, it was elected, for presentation purposes, to separate the instructional system programs from the Computational System. The reasons for the decision are:

- The Air Force has historically had problems in specifying the characteristics of the instructional system programs. There are certain unique requirements which the instructional system programs must meet and it, therefore, seems reasonable to give the instructional system programs their own subparagraph heading.

One can make the case that instructional system programs are different from what typically is thought of as software; e.g., an instructional system program, such as is required to drive a computer-assisted lesson, can be thought of as being quite different from the software needed to drive the printer or a disk storage device. And, as stated before, the requirements for these types of software are, in fact, different.

Subparagraph 3.7.3 presents the characteristics of the other major components of the trainer, such as the student station and the instructor station. As mentioned above, part of the student station and instructor station are described elsewhere in this specification. In this subparagraph you should describe only the characteristics of the student station and instructor station which are not described elsewhere.

This pre-organized presentation can be altered if the preparer feels the need (e.g., 3.7.1 can be made to describe the instructor station, etc.). However, such a reorganization would require renumbering the paragraphs and subparagraphs offered in the generic specification.

To avoid reorganizing and renumbering, the preparer might find it more economical to present the major components in subparagraph 3.1.3 in the order suggested above.

3.7.1 INSTRUCTIONAL SYSTEM PROGRAMS.

"a. The instructional system programs, as defined herein, shall support the trainer and its training mission as defined herein."

"b. All instructional system programs specified herein shall be considered as part of the computer program system and, as such, shall meet the requirements specified in subparagraph 3.7.2 and its subparagraphs. Additionally, the instructional system programs shall meet the requirements specified in this subparagraph and its subparagraphs."

"c. All instructional system programs specified herein shall be interactive, permitting the instructor to modify the status of the system or subsystem being simulated as well as alter the instructional features parameters controlling the learning situation, so that training exercises or problems can be created for training purposes.

"d. The instructional system programs shall be functionally organized as follows: ________________________
____.

Rationale and Guidance: This subparagraph consists of four items; only item d requires input. However, since this is the first time instructional system programs are discussed in this specification, an attempt will be made to define what is meant by instructional system programs.

First, the purpose of instructional system programs is to support the trainer and its training mission. Item a makes this perfectly clear to the contractor or vendor.

Second, instructional system programs are software and, as such, are to be considered as part of the Computer Program System (CPS). Since they are part of the CPS, these programs shall meet the requirements established in subparagraph 3.7.2 and its associated subparagraphs. The purpose of item b in this subparagraph is to inform the vendor of these facts.

Although instructional programs are part of the CPS, they are somewhat different than other software (i.e., somewhat different than the operating system, the software that controls the peripheral devices, etc.). Because they are different, they are given their own subparagraph heading and identification number.

Thirdly, instructional system programs are those programs that control the training or training situation. That is, they are those programs that the instructor can use to "create" training exercises and modify the training environment or conditions. They are the modification programs. If anything, they are closer to the definition for mission support programs. However, they are different than mission support programs in two ways:

- Typically, instructional system programs are interactive.

- Mission support programs are limited to the automatic generation of data which define specific systems or subsystems being simulated. The term "instructional system programs", as used here, has broader implications. It is broader in the sense that instructional system programs, in addition to allowing the instructor to change or alter the status of the system or subsystem being

simulated, allow the instructor to control (through software) the parameters controlling the learning environment; e.g., allow the instructor to change the standard value against which student performance is compared.

Instructional system programs, then, can be defined as programs (software) which are interactive and allow the instructor to change the status of the system or subsystem being simulated, as well as the parameters controlling the provided instructional features as specified in subparagraphs 3.2.1.5 through 3.2.1.5.9 of the Prime Item Development Specification, for instructional purposes. This definition of instructional system programs is the content of item c within this subparagraph. It is the instructional system programs of the CPS that allow the trainer to become a more useful training tool, to become instructionally usable. For example, if the instructional system programs are designed correctly, then the instructional system programs will permit the instructor the opportunity to create "new" training exercises - exercises which can be tailored to the needs of the operational equipment; i.e., exercises that reflect any changes in the operational equipment which require changes in the training.

Notice that this concept of instructional system programs gives the instructor maximum freedom in using the trainer as a training tool because it provides the opportunity to "build" additional training exercises. This "building" occurs as a result of the instructor interacting with the computer to vary the range of parameter values in the system being simulated, as well as the parameter values associated with the instructional features.

Item d requests the instructional system program functional organization; i.e., what programs' make up the instructional system program system. Instructional system programs can be thought of as falling into three major categories:

- Those programs which allow the instructor to input specific system or subsystem parameters so that the status of the system can be varied on any given exercise. These are called training/simulation programs.

- Those programs which allow the instructor to input parameters which control the learning environment (e.g., allow the instructor to change the value that student performance is compared against to derive the students' scores). These programs are called instructional features programs.

- Those programs which allow the instructor to change or alter the messages or instructional text that appear on

the graphic display (e.g., to alter the text that appears during computer-assisted remedial instruction). These programs are called instructional text programs.

Each of these different types of instructional system programs is discussed in the Performance Parameters section of this subparagraph. Before going to the Performance Parameters section, however, it might be beneficial to give an example of an instructional system program so that the intent of this subparagraph is not misunderstood.

One of the most useful types of instructional system programs is the one that would allow the instructor to create "new" malfunction problems that are added to the malfunction menu. Typically (in the past), the trainer was designed with a set of preprogrammed malfunctions. The instructor would select the malfunction to be presented to the student from a list or menu of malfunctions. Although this is useful, often, as the operational system was used in the field, new malfunctions would be observed. If the trainer was only capable of presenting the pre-programmed list, then the training could not keep pace with actual field-observed malfunctions. Provisions should be made for creating additional malfunction conditions using interactive software. That is, the Air Force is put at a severe disadvantage if only the malfunctions initially designated can be implemented. Changes in actual equipment field conditions and maintenance coucepts continue to occur during the life of the weapon system. The simulator must be sufficiently flexible to accommodate these changes. Provisions must be made to allow the instructor to create "new" malfunction conditions in the maintenance trainer; i.e., the instructor should be able to sit at a terminal, and using some type of computer commands (similar to word processing commands), create any set of malfunction conditions desired. This type of malfunction creation requires software. The commands entered by the instructor must be "read" by the computer and the specific malfunction should appear or at least be ready for presentation. For example, the instructor should be able to sit at the terminal and "instruct" the computer or processor to have display XYZ read or display value ABC, signifying a certain malfunction. Notice that this type of capability is different than selecting a malfunction from a menu of possible malfunctions. The ability to select a malfunction condition from a menu restricts the instructor to presenting only certain malfunction conditions (conditions which are pre-programmed). The type of capability being discussed here allows the instructor to add to the menu, to add new malfunctions or new malfunction conditions, creating a whole new problem exercise for the student. Such a capability allows the USAF maximum freedom in using the trainer. It should also be pointed out that the type

of software requirements being suggested here are not programming capabilities on the part of the instructor. Malfunction creation, as described above, requires the contractor or vendor to provide the software which would allow the instructor to specify malfunction conditions; i.e., interactive software.

A possible scenario of the intent desired would be something like this. The instructor would "call" from a menu of programs a "Malfunction Creation Routine," either by entering the program name or by entering a code for the program. The processor would respond (on a CRT) or some other device, "What part or component is to be failed?" The instructor would respond by entering the part name or a code for the part. Next the processor would ask, "How do you want the part to fail?" and offer a possible menu of the ways the part can be failed. The instructor would then specify how the part is to fail. A more sophisticated software design might require the instructor to respond to the question, "Under what condition is the failure to occur?" After the instructor specifies all the requirements, the processor would add the newly instructor-created malfunction to the menu of possible malfunctions.

Software of the type described above is also appropriate for other instructional features. For example, a scenario for a possible automatic freeze control might go something like this: The instructor from the terminal would "call" the "Automatic Freeze Control Program." The computer would then ask, "When should the trainer freeze?" The instructor would then specify the freeze conditions, either by specifying the conditions or using a possible code for the conditions. The conditions of the freeze would then be stored within the computer memory or put on file to be retrieved later. In addition, the processor might ask the instructor to specify how the freeze is to be deactivated. Again, such information could be put either on file or directly into the computer memory.

Subparagraph 3.7.1 and its associated subparagraphs are included in the specification so that the requirements for these types of programs can be fully specified.

Performance Parameters: Only item d of this subparagraph requires input.

Item d requests the functional organization of the instructional system programs. A functional organization is offered below:

"(1) Training/Simulation Programs.

(2) Instructional Features Programs.

- Malfunction Exercise Selection and Creation Programs.
- Monitoring Student Performance Programs.
- Freeze Capability Programs.
- Augmented Feedback Capabilities Programs.
- Next Activity Control Features Programs.
- Cue Enhancement Control Features Programs.
- Sign-In Capability Programs.

(3) Instructional Text Programs.

- Computer-Assisted Instruction Programs.
- Remedial Training Programs."

Item d of this subparagraph only requires the preparer to specify the functional organization for the instructional system programs. Each of these types of programs is discussed in more detail in other subparagraphs.

The subparagraph following this subparagraph establishes some general requirements for all the programs classified as instructional system programs. The subparagraphs following that subparagraph are dedicated to each of the types specified above.

Background and Sources: This is a new requirement. See AFHRL-TP-84-49 paragraphs 2.6.2.2, 2.6.2.7, 2.7.2.6, and 2.7.2.7 for information on logistics factors associated with modification and update of instructional system data and programs.

Lessons Learned: Instructional system programs are designed to give the instructor maximum freedom in using the trainer as an effective training tool. That is, instructional system programs allow the instructor to create "new" exercises. Often in the past, the instructor was restricted in using the trainer. The trainer was designed to present only those exercises that were planned for and built into the trainer. The requirement established in this subparagraph makes it possible for the instructor to create new exercises and to have more control over the trainer so that it can be more effective for training purposes.

The instructor must have freedom in using the trainer; i.e., must have control over the trainer (rather than the trainer controlling the instructor). Instructors must not be restricted by the trainer to presenting only those exercises which are initially "built" into the trainer. The instructor needs to interact with the software, so that new training exercises can be created and learning condition parameters can be modified and set for a given training exercise.

It is difficult to recommend which type of software in this area might be needed. For example, not enough is known about which instructional features are better controlled via software or better controlled using manual (non-automated) controls. More research studies need to be conducted concerning the training effectiveness and cost effectiveness of computer and manually controlled instructional features before firm recommendations can be made as to which instructional features should be controlled by software.

3.7.1.1 GENERAL REQUIREMENTS.

"All interactive instructional system programs specified herein shall have the following requirements:

a. Responses to the interactions shall be made by the instructor. All responses shall be straightforward and require the instructor to enter simple commands, words, phrases, or codes on the provided keyboard.

b. All computer-generated questions requiring an instructor response shall be displayed on the provided display system.

c. All responses entered by the instructor shall be displayed on the provided display system.

d. Provision shall be made to obtain a hardcopy printout of all computer-generated questions and instructor input to those questions upon instructor demand.

e. All interactive sessions shall be designed to permit the instructor to change or alter an input previously made, without the need to restart the interactive session. Changes or alterations shall be requested before the input information is received by the simulation program requiring or using the input information.

f. All response opportunities shall have built-in edits. If a command, word, phrase, or code entered by the instructor is out of range or otherwise illegal to the using software, the interactive program shall generate error messages on the display system.

g. All response opportunities shall have default values, if no input is entered by the instructor. All default values shall be identified at the critical design review.

h. Once all parameters have been entered by the instructor during an interactive session, the interactive software shall ask the instructor if the information input is to be saved. If the input is to be saved, the interactive software shall add the exercise automatically to the exercise menu, allowing the entire exercise to be retrieved upon instructor request.

i. Once input information is stored, software shall be provided which will:

- Delete the newly created exercise from the menu.

- Modify or edit any parameter, word, command, or phrase entered, without the need to restart the interactive session.

j. Interactive programs shall temporarily alter any individual parameters specified herein in less than 10 seconds without permanently altering the initialization set.

k. ____
____.

<u>Rationale and Guidance</u>: This subparagraph establishes some general requirements for the interactive instructional system programs. No input is required unless the preparer wants to either modify some of the provided requirements or add more requirements to the list.

Modifications to the current list are suggested in the <u>Performance Parameters</u> section of this subparagraph.

<u>Performance Parameters</u>: For convenience, each of the requirements listed in this subparagraph is explained. If modification of the requirements is possible, it is discussed.

Item <u>a</u> of this subparagraph requires that all responses made during the interactive session are to be made by the instructor; i.e., all responses shall be made by the instructor at the keyboard and all responses shall be straightforward requiring the instructor to enter a word (e.g., "Yes" or "No"); a command (e.g., reset); phrase (e.g., perform audit); or a code (e.g., part #NXXX). As stated, the requirement does not stipulate the nature of the responses. If the preparer desires to place some requirements on the nature of the interaction responses, the following should be considered:

- "All responses shall be no more sophisticated than those required of commercially available word processing programs."

- "Preference shall be given to those responses which parallel the responses of the operation of the actual equipment, if the actual equipment requires the use of input words, phrases, or commands."

(Note: Instructors are typically maintenance experts; thus, it can be assumed that they are familiar with the operational equipment. If the operational equipment is computer-driven, it may require the insertion of input commands. If it does, then it makes sense to have the interactive program require or parallel these commands).

Item b and c of this subparagraph require that all computer-generated questions and instructor supplied responses be displayed in the provided graphic display system (e.g., the CRT).

Item d requires that the interaction session (computer-generated questions and instructor responses) be recorded in hardcopy format. As a modification to the statement, the following should be considered:

- "The request for the hardcopy printout shall be interactive."

- "The request for the hardcopy printout shall be made at the beginning of the interaction session."

- "The request for hardcopy printout shall be made at the end of the interaction session."

- "The hardcopy printout shall be provided at the end of the interaction session. It is not necessary for the printer to duplicate the CRT screen at each response point."

Item e requires that the instructor (inputter) have a change opportunity at the end of the interactive session, before the input is accepted by the software needing the input to operate. This allows the instructor to change or alter any of the responses made during the interaction session.

Item f places requirements on the interactive software to have built-in edit checks and/or error messages. If the instructor inputs a parameter which is out of range, the software, at the

time of the input, should inform the instructor that the entered parameter is out of range and that a new input value or parameter must be entered. The following additional requirements should be considered:

- "As a minimum the error message must repeat the entered value and the legal ranges."

- "Upon an error message, the software shall automatically request the new value."

Item g specifies that default values be established for all interactive responses. This is to protect the software requiring the input entered during the interactive session. Consider the following for additional requirements in this area:

- "Default values shall be printed on the requested hardcopy specified in item b above."

- "All default values shall be the normal condition values."

Item h specifies that after the interactive session, the instructor shall have the opportunity to specify that the inputs are to be stored and added to the exercise menu as an exercise. Once added to the menu, the exercise can be retrieved without the instructor recreating it in another interactive session. Notice that all the entered inputs are stored as one exercise and retrieved as one exercise.

Item i concerns itself with exercises created by the instructor and stored on the available storage devices. Once an exercise is stored, programs are needed to update and modify those exercises. As a minimum these programs should allow the instructor to delete the created exercise from the menu of exercises and permit the instructor to change any input value in a given exercise to create new exercises. Other requirements can be added to the list provided in item i, such as:

"This software should automatically delete the parameters entered so that space is made available for other exercises."

Item j specifies that the parameters set during an interactive session are only temporary unless they are to be saved for future retrieval. In addition, item j stipulates that there will be no permanent altering of the initialization set; i.e., when the training exercise is completed, the initialization data will be operational.

Item k allows the preparer to insert any other interactive software requirements.

Any of the general requirements listed within this subparagraph can be deleted by the preparer if they are considered inappropriate.

Background and Sources: This is a new requirement.

Lessons Learned: This subparagraph establishes the general requirements for the instructional system programs. Notice that all the requirements are designed to make the trainer a more dynamic training tool. These interactive requirements make it easy for the instructor to create new exercises as well as control the instructional environment.

Trainers purchased in the past have been called restrictive by the instructors, meaning that the trainers could not easily be modified for training purposes. The purpose of these interactive programs is to give the instructor maximum control over the trainer. These programs permit the instructor to create new exercises, etc.

3.7.1.2 TRAINING/SIMULATION PROGRAMS.

"The training/simulation program requirements shall be as follows:

a. Interactive software shall be provided which allows the instructor to change the status of the system being simulated by altering values in existing data bases (within specified units of those values) or by supplying commands which require the simulation software to change the status represented by the simulation software.

b. Those parameters which can be changed or altered by the instructor using this interactive software shall be identified in the critical design review. Also identified shall be the range of those parameters which can be entered by the instructor.

c. ____
____
____."

Rationale and Guidance: This subparagraph only requires input in item c. If additional requirements are needed, they should be listed in item c.

Training/simulation programs are programs which allow the instructor to change system parameters for training purposes. Since trainers are often designed early in the acquisition cycle, it is difficult to keep the trainer current with the operational equipment. For example, a parameter in the actual equipment may be higher or lower than that represented on the trainer. Often this creates training problems (instructors must explain why the trainer does not trace the T.O.s). Instructors should be able to (through interactive programs) make some of the necessary adjustments in the trainer. Although major changes could be made through modification support programs, there is some advantage to having the instructor be able to interact with the computer to make the adjustments immediately. In addition, the instructor may need the flexibility to alter system parameters purely for training purposes. That is, for demonstration purposes the instructor may want to have the trainer react in an extreme manner. As the student progresses in efficiency, this extreme trainer reaction can be lessened by the instructor, slowly changing system parameter values to more normal values. In addition, the instructor may want to demonstrate complex interactions (interaction of components). These can be partially demonstrated by altering system parameters if the instructor has the freedom to accomplish this with interactive programs.

It is not being suggested here that the instructor have the responsibility to input all initial values of the systems. The initial values are handled by the simulator support programs specified under subparagraph 3.7.2 of this specification. The program being discussed in this subparagraph allows the instructor to change these values to create new exercises solely for training purposes. The values or parameters to be entered by the instructor only specify how the trainer is to behave for a given exercise. The initialization program should allow a range of values to be input, and should use the average or most likely value. The interactive program should allow the instructor, on any given exercise, to specify any value within the permissible range of values. This will not change the nature of the simulation program - only the values of the parameters in a given exercise. This type of interaction should not cause or create a need to recompile the program. Parameter value can be input and stored on a separate file for a given exercise. This would, perhaps, eliminate the need to recompile.

Notice that the requirement specifies that the parameters under the instructor's control be identified during the critical design review. This implies that not all the parameters of the system should be under the instructor's control. Only those parameters that the instructor will need to vary, for training purposes, should be changeable in the interactive program.

Performance Parameters: This subparagraph requires input only if additional requirements are to be added to those already listed in the Prime Item Development Specification.

When completing item c, the preparer should consider specifying the following:

- Those parameters which, at a minimum, must be under the instructor's control; i.e., capable of being changed by the instructor for training purposes.

- The desired ranges of those parameters which, at a minimum, must be under the instructor's control.

In addition, the preparer may want to specify the following:

> "This interactive program shall not change the values in the initialization program. The parameters entered by the instructor shall only be appropriate to a given exercise. Changes in parameters specified in the initialization program shall occur under the simulation support programs specified in subparagraph 3.7.2 and its subparagraphs herein."

Another possible additional requirement is one that requires the contractor to develop a scenario concerning how the program is to be used by the instructor.

When specifying additional requirements, make sure the additional requirements do not conflict with the general requirements specified in subparagraph 3.7.1.1 of the Prime Item Development Specification. The preparer may find it convenient, however, to duplicate some of those general requirements; e.g.,

- "The instructor shall have the opportunity to specify if the system parameters input are to be saved under a new training exercise name."

- "All system parameters entered shall have built-in edits to determine if they are within the permissible range."

Background and Sources: This is a new requirement.

Lessons Learned: This is a new requirement designed to give the instructor freedom in using the trainer as a training tool. Experience will be gained in specifying the requirement as the requirement is incorporated in future specifications. Some lessons learned have been gained from the E3A AWACS Navigational System Maintenance Procedural Simulator. This particular system

allows the changing of faults through interactive software. However, to make a change requires the manipulation of the control statements. It has been estimated that changes using the provided interactive software take 6 to 8 hours (including recompile time). This experience has indicated the need to avoid recompile time and to facilitate the changing of parameters by having a menu of these items or parameters that can be changed. The instructor can then select those to be changed and enter the new value. All values not selected for change could be retained at their present value by default.

3.7.1.3 INSTRUCTIONAL FEATURES PROGRAMS.

"Instructional features programs shall have the following requirements:

a. The following instructional features programs shall be provided: ____
____."

b. The contractor or vendor shall furnish, at the critical design review, scenarios for each of the instructional features programs listed above. These scenarios shall include, as a minimum, the following:

   (1) A description of the purpose of each program.

   (2) A listing of the parameters under the instructor's control for each program; i.e., the parameters that can be entered by the instructor, the default values, and the possible range of instructor input.

   (3) A step-by-step description of how the program is used, including illustrations.

   (4) A description of how each program can be used with other instructional features programs to create controls over the learning environment.

c. ____
____."

Rationale and Guidance: Many instructional features are software controlled. Those instructional features which are software controlled should be interactive; i.e., should permit the instructor to change certain parameters to create needed control

over the instructional environment. For example. if student performance monitoring is going to be software controlled, then the instructor should have some freedom in specifying the parameters that impact upon the student performance monitoring procedure. For example, the instructor probably wants control over the value with which the students' performance is compared. This subparagraph provides an opportunity for the preparer to specify these types of requirements.

This subparagraph contains two blanks to be completed by the preparer. The first blank, item a, requires the preparer to specify all the instructional features programs that are to be provided by the contractor or vendor. Item b contains no blanks. The second blank occurs in item c. In item c the preparer should insert any additional requirements for the instructional features programs.

The preparer may find it convenient to have a separate subparagraph for each instructional features program specified in item a. For example, if one of the instructional features programs required is a "Malfunction Creation Program," then subparagraph 3.7.1.3.1 might be titled MALFUNCTION CREATION PROGRAM. This organizational technique should be employed if there are a lot of requirements unique to each instructional features program.

Performance Parameters: Only items a and c of this subparagraph require input. However, item b may require modification to tailor it to the current application; as such, item b is also discussed below.

Item a requests the preparer to list all the programs belonging to this category. Guidance on which programs to list can be obtained by reviewing subparagraphs 5.2.1, 5.2.2a, 5.2.2b, 5.2.3, 5.2.5, 5.2.6, 5.2.7, 5.2.8, and 5.2.9 of the ISD-Based Training Equipment Design Specification. Item a only requests that the programs be listed. However, if a separate subparagraph for each program in this category is not going to be developed, then the preparer should not only list the programs but should also describe them.

For convenience, possible instructional features programs are discussed below. This list should not be considered comprehensive or exhaustive. It is difficult to suggest to the preparer what instructional features programs should be included in the specification. To a large extent, this depends upon the nature of the trainer. The preparer should check with the ISD analysts before preparing this subparagraph.

Malfunction Exercise Selection and Creation Programs. There are two types of programs within this subcategory. The first type allows the instructor to select a malfunction condition from a menu. The second type of program allows the instructor to create new malfunction conditions (training exercises) which can be added to the malfunction menu (list) and recalled or retrieved later. The first type of program already exists in some maintenance trainers; it implies that malfunction conditions have been pre-programmed. The second type is a fairly new concept. The malfunction creation program would allow the instructor to specify which component is to fail, how it is to fail, when it is to fail, etc. Typically, the malfunction creation program would be selected from a list of programs. Once called and loaded, the program would perform the following:

- List all the parts or components which could be failed via the software and request that the instructor enter a part code number or identifier for the part or component that is to fail.

- Next, the program would ask the instructor to specify how the component or part is to fail (perhaps after giving a list of ways it can fail). The instructor would then enter a code signifying how the part or component is to fail.

- Next, the program may ask the instructor, "Under what conditions is the failure to occur?" The instructor would then specify the conditions by entering commands or codes.

- After all such interactions, the program would ask, "Do any of the entered parameters need to be changed or modified?" A "Yes" response would be followed by a parameter identification code to be entered so that the parameter could be changed.

- After all parameters are final, the program would ask, "Do you want to save this as a malfunction?" A "Yes" response would automatically add the created malfunction to the malfunction menu for future retrieval.

The above scenario is only an example of how the malfunction creation program might work. A direct quote is not offered and the preparer should prepare the precise words that are to be inserted into the specification; e.g.,

"There shall be two types of malfunction instructional features programs. One program shall allow the

instructor to select, from a menu, the malfunction to be presented by the trainer for the student exercise. The other shall allow the instructor to create new malfunction conditions. The latter program shall prompt the instructor so that the new malfunctions can be created. As the minimum, the prompts shall request:

- The identification of the part or parts to be failed (possibly from a list of such parts).
- The way the part is to fail (i.e., specify how the part is to react).
- The conditions under which the part is to fail.
- If any changes of the input are required.
- If the instructor wants the new malfunctions saved."

Monitoring Student Performance Programs. These are instructional features programs which monitor the student's performance of a given exercise on the trainer. These programs, typically, record the student's responses, compare the response to a standard and then print the student's score. This program may function in the following way. Once called and loaded, the program might:

- List the student's responses to be scored or recorded and then ask the instructor to input those he or she is interested in having the computer keep track of (e.g., performing a certain action before another action). Notice that these would be training exercise specific.
- Next, the interactive software might ask, "What standard should the student's performance be compared against?" The instructor might enter a time standard, a sequence standard, etc.
- The software would then ask, "Do you want a printout of the student's performance, or do you want the record to appear on the CRT screen?" The instructor would then specify the particular desired choice.
- Next, the software might ask, "Do you want the student's score kept on file?" The instructor would then enter "Yes" or "No."
- Next, the software might ask, "Do you want this scoring or monitoring strategy to be placed in a menu of scoring routines?" The instructor would then respond, "Yes" or "No."

Notice that this interactive program is different than most student monitoring functions performed by existing trainers. This program allows the instructor to specify which responses should be monitored. Typically existing trainers, if they have a monitoring function, monitor all responses or none. Monitoring all responses may be desirable in some situations, but not all. Often the instructor is interested only in certain responses during a student's development. Thus, the instructor should have the option concerning which response should be monitored and when. Notice that if the trainer is responsible for monitoring all responses all the time, the computer would be extremely busy. In fact, the computer might decrease simulation response time simply because all responses must be monitored. It seems more reasonable to allow the instructor to have freedom in selecting which responses should be monitored and when.

The contractor or vendor should be directed to subparagraph 5.2.5 of the ISD-Based Training Equipment Design Specification and subparagraph 3.2.1.5.3 of the Prime Item Development Specification for information concerning what responses could and should be monitored, as well as what standards might be used for each response.

For completeness, the following words are suggested:

> "The student monitoring program shall allow the instructor to specify the following before each exercise:
>
> . The responses which are to be monitored during the exercise.
>
> . The standard to which the student's response will be compared.
>
> . The need to have the student's responses printed on the printer after the student completes the exercise.
>
> . The need to have the student's response and/or score kept on file."

<u>Freeze Capability Programs.</u> These are instructional features programs which allow the trainer to freeze for instructional purposes or for safety reasons (both personnel injury and equipment damage).

On any given learning exercise, the trainer can be pre-programmed to freeze under certain conditions (see subparagraph 3.2.1.5.4 of

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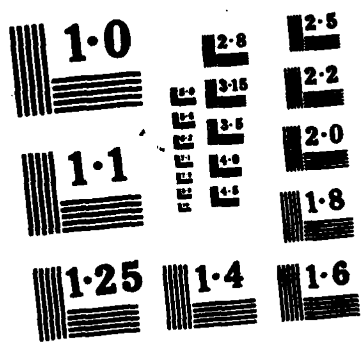
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the Prime Item Development Specification). Thus, one aspect of this type of program is to have a normal or usual freeze condition; i.e., the preparer may want to specify:

> "A software program shall be written which provides the freeze capability discussed in subparagraph 3.2.1.5.4 herein. This program shall not be interactive, but shall represent the normal freeze circumstances for each practical learning exercise."

In addition to the pre-programmed freeze conditions, the contractor or vendor should provide an interactive program which allows the instructor to alter the pre-programmed freeze conditions specified in the software described above. That is, this interactive program should allow the instructor to change the following parameters for each learning exercise:

- When the freeze is to occur; can be specified by:
  - Student actions.
  - System status after a set of student actions.
- When the freeze is deactivated; can be specified by inserting or inputting a set of instructor actions.
- What occurs when the freeze condition is deactivated (what is the next learning activity).

This software should be called before each learning exercise and the input entered by the instructor. In addition, the software should ask the instructor if the entered parameters should be saved for future retrieval.

For completeness, the following wording is offered for consideration:

> "The interactive freeze capability program shall allow the instructor the opportunity to specify the following before each exercise:
>
> - When within the exercise the trainer is to freeze. This shall be specified either by student action or system status after a student response.
> - When the freeze is to be deactivated.
> - What occurs when the freeze is deactivated."

Augmented Feedback Capability Programs. These are programs which control how and when augmented feedback is given to the student during a practical exercise. Augmented feedback should not be confused with the direct feedback the student receives from the trainer as a result of performing a specific action. Augmented feedback refers to the written or verbal feedback the student receives on the correctness of the responses as well as the reasons why the responses were correct or incorrect.

The interactive software concerning augmented feedback should provide the instructor an opportunity to specify the following information for each practical exercise:

- When during the practical exercise should the augmented feedback be presented to the student (i.e., the augmented feedback schedule - immediately after a student response or a delayed feedback schedule).

- The content or text of the feedback message (What should the student be told?). Typically, the feedback message will depend on the nature of the student's response. Thus, the instructor will need the opportunity to specify contingency feedback messages. Feedback messages usually contain information concerning the correctness of the student's response as well as the reason why a particular response is correct or incorrect.

- The device which will be used to communicate the feedback message (CRT, printer, slide projector, etc.).

Before preparing the description of this interactive program, the preparer should read subparagraph 3.2.1.5.5 of this specification.

For completeness, the following wording is suggested for this requirement:

> "The augmented feedback program shall allow the instructor, as a minimum, to specify the following during the interactive session:
>
> - When the augmented feedback message shall be presented to the student.
> - The content of the feedback message.
> - The device which will be used to present the message."

Next Activity Control Programs. These are programs which direct the student to the next learning activity after completing a specific learning exercise.

Some of the next activities can be pre-programmed (see subparagraph 3.2.1.5.6); i.e., they can be specifically determined for some exercises. However, the instructor may desire some freedom in altering the selection of the next activity for a given exercise. Thus, the interactive program should permit the instructor to determine, for a given exercise, the following:

- What the next activity shall be following a specific learning exercise (i.e., change the pre-programmed next activity).

- Determine a new sequence of pre-programmed next activities from a menu of pre-programmed activities.

The following wording might be used to specify this requirement:

> "The interactive next activity control program shall allow the instructor to specify the following before each exercise:
>
> - What the next student activity shall be after the completion of the exercise.
>
> - A new sequence of controlled next activities."

Stimulus Control Programs. These are programs which control the rate of stimulus presentation and the ratio of signal to noise. Subparagraph 3.2.1.5.7 of this specification provides a list of presentation rates and signal to noise ratios for each learning objective or learning exercise. If the trainer is to control these rates (via the computer), then programs will be needed. If the instructor desires freedom in selecting these rates, then an interactive program will be needed; i.e, a program which allows the instructor to change the rates and ratios for a given learning exercise. This interactive program, like the others being described, should be called before each learning exercise by the instructor. The interactive software should then request the following input from the instructor:

- After the software identifies in a menu fashion the stimuli that can be controlled by the software, the program should request the instructor to identify which stimuli are to be controlled for this particular exercise (by entering a code for each stimulus).

- The software should then request the instructor to enter the rate of stimulus presentation for each stimulus identified by the instructor as needing control (this can be entered as the number of stimuli per minute).

- After the stimulus rates have been identified, the software should request the instructor to identify from a list (menu) those stimuli which are to have their signal-to-noise ratios controlled.

- After such identification, the software should request the instructor to enter the appropriate signal-to-noise ratio for each stimulus identified.

For completeness, the following words are suggested to specify this requirement:

"The interactive stimulus control program(s) shall allow the instructor, as a minimum, to specify the following parameters before each practical exercise:

- The stimuli that are to be controlled for the given exercise.

- The rates at which each of the stimuli shall be presented.

- The stimuli which require signal-to-noise ratios to be controlled during the exercise.

- The specific signal-to-noise ratio for each stimulus selected as needing control."

Cue Enhancement Control Programs. These are programs which control the highlighting of cues during a given learning exercise. Subparagraph 3.2.1.5.8 of this specification lists the cues which shall be highlighted during specific exercises. If the highlighting is to be computer-controlled, then a program will be required. This program need not be interactive unless the instructor requires the freedom to select what cues are to be enhanced during the application of specific exercises; i.e., if the instructor wants the freedom to redefine the highlighted cues. If the program is to be interactive, then the following should be requested by the interactive program:

- The software should list the cues which can be highlighted via the software. After the menu is presented, the interactive software should request the instructor to specify by code those cues which are to be highlighted.

- For each cue identified, the interactive software should then request that the instructor specify how the cue is to be highlighted (perhaps the software could list the available methods for highlighting each cue).

For completeness, the following is suggested to specify this requirement:

> "The interactive cue enhancement program shall allow the instructor to specify the following for a given exercise:
>
> - The cues which are to be highlighted in the given exercise.
>
> - The procedure used to highlight the specified cue, if more than one procedure is available."

Sign-In Programs. These are programs which control the student sign-in function. The sign-in capability of the trainer is specified in subparagraph 3.2.1.5.9 of the Prime Item Development Specification. If the sign-in function is to change or the instructor wants the freedom to alter the data items requested during the sign-in, then an interactive program would be needed. If an interactive program is required, then it should allow the instructor to specify what data are to be collected during the sign-in activity, such as:

- Student's name.
- Student's ID.
- Exercise number.
- Attempt number (number of practices permitted).
- Controls on learning environment.

For completeness, the following wording is suggested:

> "The interactive sign-in program shall allow the instructor to specify the items to be entered by the student during sign-in."

The preparer will have to select which of the above instructional features software is needed. Partial guidance can be obtained by reading subparagraphs 3.2.1.5 through 3.2.1.5.9 of this specification. After the selection is made, the preparer should list the required programs in item a. If each program is not to be given its own subparagraph heading, then the preparer should describe the nature of the software program; e.g.,

> "The following instructional features programs shall be provided:

a. Malfunction Exercise Selection and Creation Programs. Two programs shall be provided. One shall allow the instructor to select a malfunction exercise from a menu of exercises. Once a malfunction is selected from the menu, the program shall cause the trainer to simulate the malfunction conditions of the selected malfunction exercise. The simulation shall be in accordance with the parameters specified in subparagraph 3.2.1.5.2 herein. The second program shall allow the instructor to create new malfunction exercises. All created malfunction exercises shall be automatically added to the malfunction exercise menu. Creation of malfunction exercises shall be obtained by permitting the instructor to specify parameter values in the system being simulated so that the malfunction conditions are presented to the student.

b. Freeze Capability Programs. Two programs shall be provided. One program shall cause the trainer to freeze in accordance with the requirements specified in subparagraph 3.2.1.5.4 herein. The second program shall be interactive. The second program shall permit the instructor to specify, for each exercise, the following information:

- The conditions which will cause the trainer to freeze (i.e., student actions which require a freeze).

- When the freeze shall be deactivated (recovery procedures)."

The above example requires only two instructional features programs. Notice that, for each program, the software is fully described. Included in the descriptions are the parameters can be set by the instructor during the interaction session; that i.e., the values which need to be under instructor control.

The preparer should develop such descriptions for each type of instructional features program that is required. These descriptions can be developed from the information provided in this section.

Item b of this subparagraph requires no input from the preparer. Item b is included to assure that scenarios are developed for each instructional features program. The scenarios are provided at the critical design review so that the Air Force can be assured these software programs are designed and function in the way they were intended. These scenarios should include a description of the program (its intent and purpose), a list of

the parameters that can be manipulated by the instructor, and a discussion of how all the required instructional features programs interact to create interesting learning environments. These scenarios should be as detailed as possible, showing the questions the computer will ask the instructor, specifying the order of those questions, identifying the range of permissible responses to those questions, and indicating the edit checks for each of the responses.

Item c is provided for inserting any other requirements for the instructional features programs; e.g.,

> "All instructional features programs specified herein shall be called by the instructor before each practical exercise. A supervisory program shall be provided which is interactive. The supervisory program shall list a menu indicating which instructional features programs can be called as well as the order of the calls (if a specific sequence is required). The supervisory program shall summarize the instructional features programs that were called and indicate that those not called will operate with the initialized parameters."

Background and Sources: This is a new requirement. The preparer should carefully review subparagraphs 3.2.1.5 through 3.2.1.5.9 of the Prime Item Development Specification before preparing this subparagraph. The information presented in this subparagraph must be consistent with the requirements specified in 3.2.1.5 through 3.2.1.5.9. In addition, the list provided in item a of this subparagraph must be consistent with the information provided in subparagraph 3.7.1 of this specification.

Lessons Learned: The preparer should be cautioned that not much is known about specifying instructional features software requirements. It is important, however, to stress that the instructor needs the freedom to use the trainer for training purposes; i.e., have control over the learning environment to be presented by the trainer. The instructor needs to be able to adjust the parameters that control the learning environment.

This particular subparagraph of the Prime Item Development Specification requires the contractor or vendor to furnish, at the critical design review, scenarios for each of the instructional features programs. It has been suggested that some contractors or vendors may not have the in-house capabilities or expertise to fully present a scenario or scheme for such instructional features programs; i.e., they may not be aware of the capabilities that are available in computer-controlled instructional features. It has also been suggested that some contractors or

vendors may not really perceive the instructional features software requirements as important. This limited view may limit the flexibility the instructor needs in controlling the learning environment. To ensure adequate use of implemented instructional features, the contractor or vendor should (by contract) prepare a review of past trainers' instructional features and suggest additional software features.

It should also be pointed out that software is not the only way to control the instructional features. Some instructional features' controls can consist of buttons and switches located on the instructor station. These buttons or switches could be used to set the level of cuing, the scoring routine, etc. These buttons and switches can, in certain applications, take the place of the interactive programs discussed in this subparagraph. However, the ISD analysts should be consulted.

It should also be emphasized that the more parameters that are software-controlled, the more computer space and storage space that are required. Thus, the more instructional features software, the larger the computational system must be. Furthermore, the preparer should be warned that the more the computer must do during a given exercise, the more likely that response time will be decreased. For example, if a student performance monitoring function is assigned to computer control and a given exercise requires the computer to track or monitor all the responses, then the time it takes for the computer to do this might detract from the computer's response time.

3.7.1.4 INSTRUCTIONAL TEXT PROGRAMS.

"The instructional text programs shall have the following requirements: ____________________ ____________________."

Rationale and Guidance: Instructional text programs are those programs that control computer-assisted instruction functions. This subparagraph should be included in the Prime Item Development Specification only if there is a need to have computer-assisted instructions (either as remedial instruction or as a mode of primary instruction).

In specifying the requirements for these types of programs, consideration should be given to the following:

- Computer-assisted instruction usually consists of frames (text material) presented on a CRT screen. Since text

material can change, the instructor should have a program which allows him or her to add, delete, and change the information on any text frame.

- If computer-assisted instruction is going to be provided, then it seems reasonable that the instructor might want to create his or her own computer-assisted instruction packages. This means that a creation program will be needed.

- A run program will also be needed to run the information on the entered frames.

Performance Parameters: The preparer should insert the requirements for the instructional text programs.

The following requirements are suggested:

> "The contractor or vendor shall provide computer-assisted instruction for the student in the following areas: ____
> ____."

The preparer should insert the areas to be taught via computer-assisted instruction. This information can be obtained from the ISD analysis.

> "The provided computer-assisted instruction program shall have the following requirements:
>
> a. The program shall display the text material (frames) on the provided CRT.
>
> b. Each frame shall have enough space for 20 lines of text materials, with 80 characters per line.
>
> c. Each frame shall allow student responses made from the provided keyboard. Each frame shall permit branching, depending upon the student's response. At a minimum, four branches shall be provided at each frame.
>
> d. The computer-assisted instruction software shall record the responses made by the student at each frame that requires a student response. The correctness of the response shall also be recorded. At the end of the session, the student's score shall be printed on the CRT. An option shall be made available to have the student's score printed in a hardcopy format.

e. The computer-assisted instruction software shall permit the student to start at any frame by entering a start frame number or code."

If the instructor requires the capability to edit the provided computer-assisted instruction frames, then the following should be inserted:

"Software shall be provided for the instructor to edit the material on the frames. These edit programs shall be interactive and, as a minimum, permit the instructor to perform the following:

a. Change letters, words, and/or sentences.

b. Add letters, words, and/or sentences within the 20-line/frame requirement.

c. Delete letters, words, and/or sentences.

d. Change, add, or delete the specified branching code; i.e., the frame that appears in the display system after a given student response."

If the instructor requires the capability to create new/additional computer-assisted instructional packages, then the following requirements should be considered.

"Software shall be provided which allows the instructor to create additional computer-assisted instructional packages. This software shall have the following requirements:

a. It shall be interactive; i.e., prompt the instructor.

b. It shall allow the instructor to enter text material by frame.

c. It shall allow the instructor to enter questions which the student must respond to in order to monitor the student's learning. Each question shall allow a minimum of four branches.

d. It shall allow the instructor to enter and specify which frame is to appear for each student response.

e. All information entered by the instructor shall be edited using the edit programs specified above.

f. Once the package is created, it shall run on the software specified above."

Background and Sources: This is a new requirement. The need for computer-assisted instruction is determined during the ISD analysis.

Lessons Learned: If a computer is going to be needed to drive the trainer, then the computer or processor can be made available for other uses. One of these uses is for computer-assisted instruction. Notice that the requirements suggested above make the software general enough so that the instructor can create new or additional computer-assisted instruction packages. This capability means that the instructor will be able to get maximum use from the provided computer and software; i.e., the computer can be used to present other types of instructions rather than being just dedicated to the trainer.

Another use of the computer is for word processing. If the word processing function is required, then it can be specified in this subparagraph; i.e., word processing can be visualized as an instructional text program. If word processing is desired, then the following requirement might be considered:

> "The contractor or vendor shall provide a commercially available word processing program which will run on the provided computer without change or modification of either the word processing program or the computer hardware."

Commercially available word processing programs are in existence for most computers on the market today. These programs are relatively inexpensive. It seems reasonable to suggest that since the computer is part of the trainer, then the purchase of a word processing program would greatly enhance the training capability of the trainer.

This subparagraph of the Prime Item Development Specification allows several options. Computer-assisted instructional text can be initially prepared by the contractor or vendor (under contract). The software discussed in this subparagraph would allow the Air Force (instructors) the opportunity to edit, file, maintain, and/or change the instructional text provided by the contractor or vendor.

The second option is not to request from the contractor or vendor the computer-assisted instructional text, but instead, to use the software as discussed above, permitting the instructors to develop computer-assisted instructional text as they need it for training purposes.

The first option allows instructors to modify "canned" instructional text material, whereas the second option allows instructors to create new instructional text materials. It should be pointed out that in either case, the instructional text material (not the software used to create or modify) must be approved in the normal manner.

3.7.1.5 DOCUMENTATION.

"a. All interactive programs specified herein shall be delivered in object format on magnetic disk and magnetic tape. Source code shall also be provided on ____."

"b. Each interactive program specified herein shall have a user's manual. This manual, as a minimum, shall contain:

(1) A description of the program.

(2) An explanation of the parameters that can be specified (including the range of legal entries).

(3) A dictionary of any terms or commands that are used during the interactive session.

(4) An explanation of the effects of using any entered terms or commands."

Rationale and Guidance: Item a of this subparagraph specifies the deliverable format of the instructional system programs.

Item b specifies that manuals are to be developed and provided by the contractor or vendor. Although deliverable manuals are usually handled in DIDs, it is important for the contractor or vendor to provide instructions on how the interactive software is to be used by the instructors. In addition to the words in this subparagraph, the preparer should be sure that the appropriate DIDs are included in the contract; e.g., DI-H-3277.

Performance Parameters: Enter the medium on which source code should be provided. Traditionally, source code has been provided on punched cards; disk or tape may be preferred. Alternatively, a hard copy may be requested.

Background and Sources: See DI-H-3277 and other applicable DIDs. Also see AFHRL-TP-84-49, paragraphs 2.1.2.5 and 2.6.2.5, for information on logistics factors associated with documentation.

Lessons Learned: The requirement for interactive programs (as specified herein) is new. In addition, the use of interactive programs may be new to instructors. Thus, it is important for the contractor or vendor to provide manuals for these programs.

3.7.2 COMPUTATIONAL SYSTEM.

3.7.2.1 COMPUTATIONAL RESOURCES.

> "The Trainer Computational Resources, hereafter referred to as the Computational System and including the Computer Program System (CPS), is herein defined to include all digital processing equipment, interface hardware, peripheral equipment, and associated computer programs/data used to operate and support all major components and subsystems of the training device. Unless noted herein, all computer programs/data (including firmware) used in the development, operation, maintenance, and support of the training device are considered to be part of the CPS and as such shall satisfy all requirements specified herein. Computational Resources shall be documented as required to support the day-to-day operation, mission support activities, modification support activities, maintenance, and test of the trainer."

Rationale and Guidance: This paragraph defines the scope of the Computational System requirements as they apply to computer resources and software used in the design of the maintenance trainer being procured. Those requirements which apply to the Computational System independent of the Computational System's architecture, manufacture, and partitioning across major component subsystems are outlined here. The purpose of this section is to assure that the Computational System requirements will be applied to all computer resources used in the maintenance trainer (i.e., embedded processors, specialized processing equipment, firmware, etc.) without forcing any specific design constraints upon the contractor. These requirements must be levied on all computer resources used in the trainer unless explicit exception is made in this specification. The location of this paragraph and its subparagraphs in the specification is critical. The requirements stated here are "system" requirements of the trainer itself. They apply to all computational resources in the trainer.

Performance Parameters: In this specification, each functional activity (i.e., computational, instructional, support, etc.) has the responsibility to define subsystem-unique hardware and software requirements which conform to the general requirements established here (all of section 3.7.2.1). It should also be noted that the requirement that all Computational Resources be documented is not a "statement of work" but rather a requirement which must be met by the delivered trainer configuration. Indeed, the Statement of Work (SOW) and the CDRL must, respectively, direct the generation and delivery of the specified documentation, just as the SOW must direct that the trainer itself be built. This specification must levy content requirements for the documentation, while the CDRL must levy format/delivery requirements, and the SOW must direct the contractor to generate documentation which meets both sets of requirements. All three must be consistent with one another, or chaos will result.

Background and Sources: None available.

Lessons Learned: In recent years, several MTDs have been procured containing computer resources which, by the nature of the specification, were considered to be independent of the Computational System and its associated requirements. As a result, support deficiencies were experienced for these computer resources. These deficiencies ranged from increased spare requirements (due to model and series number differences among the computer equipment) to complete nondelivery of support equipment, documentation and the like. In all cases where these deficiencies were observed, there was no section in the specification which levied "system" requirements on all computational resources in the maintenance trainer. The result was a proliferation of computer resources in the maintenance trainer which were not supportable or maintainable. In addition, these computer resources were released from programming language and documentation requirements which applied to the Computer Program System (CPS). This resulted in nondisclosure of the technical design of the software for the resources, which had a severe impact upon software supportability and maintainability.

3.7.2.1.1 COMPUTATIONAL SYSTEM HARDWARE.

"Hardware shall be selected for the Computational System which shall be capable of processing the total Computer Program System. The selection of Computational System hardware shall be designed to eliminate potential interface problems and minimize maintenance complexity, and to ensure supportability for the specified useful life of the trainer. Computer vendor-supplied hardware ____________

be modified. All Computational System hardware shall be designed to provide and include spare capacities and means to measure spare as specified herein."

Rationale and Guidance: This paragraph defines the general ("system") requirements for the Computational System hardware. These requirements are necessary to enhance the definition of the scope of the Computational System. The requirement for spare capacities is necessary to minimize the probability that a major modification of the Computational System will be required when normal system modifications and Time Compliance Technical Orders (TCTOs) are incorporated.

Performance Parameters: For this blank "may" or "shall not" must be selected, depending upon the support concept for the vendor supplied hardware (i.e., organic maintenance (shall not) or contractor support (may)). In most cases, "shall not" should be selected because it eliminates the risk associated with computer hardware modification and the associated support requirements.

Exceptions to the requirement can be granted if the contractor demonstrates to the Government's satisfaction that a particular modification is in the best interest of the Government. In such cases, the specification should be changed to reflect only the specific computational hardware and associated major component subsystem(s) where this exception is granted (e.g., Visual Subsystem).

Background and Sources: None available.

Lessons Learned: The requirements of this paragraph are targeted toward the elimination of supportability problems after the deployment of the maintenance trainer. A past trainer was designed using a standard computer vendor product which, by production contract award time, had been discontinued by the vendor as a standard product. This circumstance was brought on by two conditions:

a. The inability of the procuring activity to identify the use of the item due to a competitive procurement.

b. The contractor's position that the product was not Computational System hardware and therefore had been exempted from all requirements specified for Computational System hardware and the CPS.

Both of these conditions could have been avoided if the specification had levied the requirements of this paragraph. The requirements force the early identification of computer resources with unique support requirements.

3.7.2.1.1.1 MULTIPROCESSOR/MULTICOMPUTER COMPLEX.

"If a multiprocessor and/or multicomputer complex is used to meet the operational requirements of the trainer, the following requirements shall be met:

a. The configuration of processing units, interface hardware, and peripheral equipment into a multiprocessor computer configuration and the combination of these computers into a multicomputer complex shall be designed to eliminate nonproductive idle time created by inefficient processor synchronization and intercommunication except on queued microprocessors.

b. Means shall be provided for efficient buffering of data and instructions for communicating and downloading between processors (as necessary), random access memory (RAM), and mass storage equipment.

c. Each computer configuration (mini or micro) shall be capable of being loaded, initialized, and reinitialized independent of all other computer configurations such that in the event of a soft failure of that computer configuration and the associated computer programs/data, the entire computational complex will not require reinitialization resulting in the loss of the training mission."

Rationale and Guidance: The paragraph introduces the terminology which will be used to apply requirements to any Computational System architecture the contractor chooses to use in the design. The purpose here is to further establish the scope of the Computational System requirements in terms which relate to the potential design of the system. The requirement for "efficient buffering of data and instructions for communicating and downloading between processors (as necessary), random access memory (RAM), and mass storage equipment" is necessary to provide communication among of processors and computers without dictating the architecture of the computational complex. This requirement is also necessary in order to meet the requirement stated in c, which is intended to prevent deficiencies and problems in current maintenance trainers from occurring in future systems. These problems occur when the system design has limited fault-tolerant safeguards. The intent is to eliminate "re-booting" in order to assure minimum lost training due to system failure requiring reinitialization of the trainer Computational System.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: Terminology has always been a big problem in maintenance trainer procurements (as well as many other computer-based systems). There are always disputes over what a particular term means in one context as opposed to another. A typical problem is the case where processing requirements like spare time are specified to apply to "each CPU" in the system. Various interpretations of what constitutes a central processing unit (CPU) have caused many disputes of this requirement. It is normal in a multiprocessor-based computer to call only one of the processors a CPU and the rest coprocessors, auxiliary processing units (APUs), or something to that effect. This can have a serious impact on the real "processing spare" that gets delivered. Thus, it is felt that any attempt to reduce the potential for terminology disputes is a step in the right direction, even though it may seem trivial.

3.7.2.1.1.2 COMPUTATIONAL SYSTEM HARDWARE DOCUMENTATION.

> "Documentation for the Computational System hardware shall be provided with the trainer. The documentation provided shall support the operation, mission support activities, modification support activities, maintenance and test of the hardware. All commercially available vendor manuals shall be provided for vendor hardware used in the Computational System. Hardware designed or modified for the trainer shall be fully documented as specified herein."

Rationale and Guidance: This is an extension to the next lower level of the requirement stated in 3.7.2.1 for all Computational Resources in the trainer to be documented.

Performance Parameters: No input is required from the preparer. The requirement for commercial documentation to be provided for all vendor hardware must be consistent with the SOW and CDRL.

Background and Sources: None available.

Lessons Learned:

3.7.2.1.2 COMPUTER PROGRAM SYSTEM.

"All computer programs and data (software and firmware) used in the trainer collectively constitute the Computer Program System. The CPS shall support the total trainer mission including training and evaluation of students, maintenance, test, and lesson and modification support. As required by this specification, CPS computer programs/data shall be provided for all major component subsystems. The CPS shall be designed to preclude redesign and redevelopment as the result of the incorporation of computer vendor hardware, software, and firmware updates or revisions."

Rationale and Guidance: This paragraph identifies general requirements for the CPS and all elements which belong to it. The requirements of this paragraph are generic to the CPS. The requirement that the CPS be designed so as to preclude redesign resulting from vendor product revisions applies across the entire CPS and all major component subsystems which have software associated with them. The position of this paragraph as described in the guidance for 3.7.2.1 is extremely important.

Performance Parameters: These requirements and those defined in the subparagraphs below are "system" requirements of the CPS and apply across the entire maintenance trainer. Maintenance trainers of all levels of sophistication are covered by this paragraph. The paragraph states that "The CPS shall support the total trainer mission ...." The level of such support will be determined by the rest of the requirements in this specification.

Background and Sources: See AFHRL-TP-84-49 for information on logistics factors associated with software (e.g., paragraphs 2.1.2.3, 2.6.2.3, 2.6.2.4, and 2.7.2.8).

Lessons Learned: The mention of redesign and redevelopment due to computer vendor's revisions is prompted by previous problems encountered. Maintenance trainers have been developed where large amounts of software had to be redesigned due to a change in computer vendor software or equipment. This requirement is directly related to the requirement for the use of vendor operating systems and other requirements which deal with the commercial computer products used in the maintenance trainer. (See also 3.7.2.2.2 Lessons Learned).

3.7.2.1.2.1 PROGRAMMING LANGUAGE.

"The CPS shall be written in the ______________________ programming language (i.e., full language, not a subset).

All deviations to this requirement shall require a waiver and shall be explicitly brought to the attention of the procuring agency."

Rationale and Guidance: This specification and the governing regulations of the procuring activity require that all maintenance trainer computer programs be developed in a Higher Order Language (HOL).

Performance Parameters: The DoD has specified a list of approved HOLs for developing defense system software (ref. DODD 5000.29). Because of their inherent capabilities, availability, familiarity to simulator manufacturers, and the large amount of software already existing for implementing various simulator requirements, FORTRAN and PASCAL are the most suitable for training systems at present. Although USAF AFSC/ASD has directed that JOVIAL J73 be used in all ASD procurements, a waiver has been obtained approving the use of FORTRAN in maintenance trainers. In July, 1984, however, the DoD directed (DODD 5000.31, 10 Jun 83) that Ada (ANSI/MIL-STD-1815A-1983) will be the specified HOL for all "Mission Critical" computer systems (interpreted to include trainers) entering Full-Scale Engineering Development. Therefore, this blank should be replaced with "ANSI X3.9 1978 FORTRAN" or "ANSI/MIL-STD-1815A-1983 Ada" as appropriate.

It should be noted that this requirement may be waived to allow use of PASCAL, etc. under certain circumstances. For example, if an off-the-shelf, commercial visual CIG system is included in the proposed computational resources, the software running it most probably will not be written in an HOL like FORTRAN or Ada. The waiver should be granted only for those subsystems to which it applies, not a "blanket waiver" for the entire system.

Background and Sources: Sources are given above.

Lessons Learned: The design of software/firmware written in a non-HOL is usually difficult for an outsider to the design process to comprehend.

3.7.2.1.2.2 CPS ORGANIZATION AND PREPARATION.

"The CPS shall be organized into computer program/data divisions to provide insight to the development and configuration management of the CPS. There shall be a computer program/data division for each major component subsystem. Each division shall contain those computer program components (CPCs), computer program modules (CPMs), computer program elements (CPEs), and computer data files (CDFs) unique to its major component subsystem. Additional divisions (as necessary) shall

be organized for those CPCs, CPMs, CPEs, and CDFs which are common to more than one major component subsystem. Each major component subsystem division shall include subsystem support computer programs necessary to fulfill simulation requirements. The CPS shall ________________. Any programming language features and structured programming techniques that are used shall not preclude normal updates to the current configuration of computer vendor products as they are released. Computer vendor product updates shall be incorporated into the CPS."

Rationale and Guidance: The purpose of this paragraph is to ensure that state-of-the-art techniques in software development are used in the development of the CPS. The requirements identified here, along with contractual (SOW) requirements for the configuration management of the CPS, provide the procuring activity with insight into the contractor's progress in the development of the CPS.

Performance Parameters: This blank should be replaced with state-of-the-art software design requirements which do not restrict the hardware design or architecture. At present, the following is recommended:

"The CPS shall be top-down designed and hierarchically structured. The highest level (top-level) of abstraction shall consist of one or more supervisor/executive routines which shall control the execution of tasks. Tasks shall be composed of functionally related CPCs. CPCs shall be composed of simple, independent CPEs and CDFs which, when grouped together, complete functionally identifiable parts of the trainer CPS. The CPEs and CDFs shall be at the lowest level in the hierarchy. Each CPE shall consist of a unit of computer program code which shall be independently compiled and/or assembled. The source code and object code for each CPE shall be included in the delivered version of the CPS. Computer data shall be structured into CDFs. Structured programming techniques shall be applied in the design of the CPS to facilitate straightforward, comprehensible program design."

With regard to the structuring requirements, literature is plentiful about the benefits of modular and hierarchical decomposition when applied to large software projects. In most trainers, there is a large amount of software which is repeatedly used by many parts of the CPS. When the CPS is properly organized and structured, maximum use of common software CPEs can be made. These requirements encourage such an approach and apply to all Computational System hardware architectures equally well. It is

important to emphasize that most of these requirements should also have a corresponding section in the SOW. SOW (and CDRL) requirements for configuration management, the generation of software trees, software status reports, CPS organizational data, etc., must be consistent with the requirements of this section.

Background and Sources: None available.

Lessons Learned: Lessons learned for this paragraph relate to the requirement to provide subsystem support computer programs and maintenance and test computer programs for each major component subsystem. In previous maintenance trainers, the requirement for subsystem support computer programs and maintenance and test computer programs appeared only in the requirements for the Computational System. The problem was that this requirement was interpreted by the contractor as applying only to the Computational System and not as a software requirement for each major component subsystem. This was also partly due to the way the specification was structured. All software requirements for the major component subsystems were specified in a Computer Program System section of the spec and not in each major component subsystem section. As previously emphasized in this spec, it is the responsibility of each major component subsystem functional engineer to specify all software requirements unique to the particular subsystem.

3.7.2.1.2.2.1 TRAINER SUBSYSTEMS SUPPORT COMPUTER PROGRAMS.

"Computer programs/data shall be provided to support all on-line and off-line operational requirements of the trainer. Lesson support computer programs and modification support computer programs shall be provided for each major component subsystem as required by this specification. All trainer subsystems support computer programs shall satisfy the following requirements: ______________ ____."

Rationale and Guidance: This paragraph further defines the requirements for providing support programs. Two sub-classes of support programs are identified:

1. Lesson Support.
2. Modification Support.

The difference between these two classes is subtle and the definition of detailed requirements for each is totally dependent upon the using command's support concepts for the trainer. These classes are identified here in order to provide a common approach for the specification of support software required for each major component subsystem.

The basic distinction between lesson support and modification support software is who will use these capabilities and why. Lesson support functions can best be described as capabilities which are directly related to the operation of the trainer. This includes functions such as instructor lesson plan development/ modification and any other functions which the trainees or instructors must perform which are unique to the training objectives. These programs will be provided with every trainer in a multi-unit buy.

This is contrasted by "modification" support programs which support the trainer as a device simulating an environment. Examples of such software functions are:

1. Malfunctions data modification.
2. Generation of instructor station CRT pages (not lesson plans).

Also included is any other software which is necessary to modify the maintenance trainer CPS, but which is insensitive to the training lesson being conducted. These software requirements are going to be dependent upon the overall requirements for the trainer. But the one thing which they have in common is the fact that they are functions which are independent of the lesson and which will most likely be reserved for a separate trainer support activity, where changes are made that require engineering expertise and/or major changes to the CPS. Each trainer site in a multi- unit buy may or may not have the resources in personnel or delivered equipment to provide such support. Thus, in this specification, all modification support requirements have been collected into one section and called the Trainer Support Subsystem (TSS). This section may be removed or included as necessary to achieve the desired trainer configuration.

Performance Parameters: This blank should be filled in with a list of general requirements applying to all support programs developed for the maintenance trainer. Many of these requirements will, as previously stated, be dependent upon the training and support requirements for the maintenance trainer. Some requirements which should appear here are as follows:

"a. The programs shall be executable on the deliverable trainer Computational System.

b. The programs shall provide user interface through a support console.

c. All data input and output shall be accomplished using only deliverable peripheral equipment.

d. All outputs shall be directable (by choice) to a hard-copy device."

Additional requirements should be added as necessary. The basic requirement that each major component subsystem address lesson support and modification support as two separate requirements is universal and must remain in this paragraph.

Background and Sources: None available.

Lessons Learned: In a recent trainer acquisition, the requirement for lesson support programs were divided among the system requirements, Computational System requirements, and instructor station requirements in the specification. The Computational System requirements stated that the software should be designed to use input from the CRT terminal and should provide interactive error checking whereas the other sections did not. The result was that the software was initially designed to use punched card input and performed no error checking. This is a clear example of the uncoordinated design that can result from uncoordinated functional requirements in the specification.

3.7.2.1.2.2.2 MAINTENANCE AND TEST COMPUTER PROGRAMS.

"Computer programs/data shall be provided to fully test the operation of each major component subsystem in accordance with the requirements of 3.5 and the requirements specified for each major component subsystem. All maintenance and test computer programs shall satisfy the following general requirements: ____________________
____________________."

Rationale and Guidance: With analogy to the rationale for 3.7.2.1.2.2.1, TRAINER SUBSYSTEMS SUPPORT COMPUTER PROGRAMS, these general requirements are identified here in order to provide a common approach for the specification of maintenance and test computer programs required for each major component subsystem. The definition of the requirements will also be dependent on the using command's support concept of the trainer.

Performance Parameters: This blank should be filled in with a list of general requirements applying to all maintenance and test computer programs developed for the maintenance trainer. Requirements which should appear here include:

"a. The programs shall be executable on the deliverable trainer Computational System.

b. The programs shall provide user interface through a support console.

c. All outputs shall be directable (by choice) to a hardcopy device."

Additional requirements should be added as necessary.

Background and Sources: See AFHRL-TP-84-49, paragraph 2.1.2.5, for a discussion of logistics factors associated with diagnostic test programs.

Lessons Learned:

3.7.2.1.2.2.3 OPERATIONAL READINESS COMPUTER PROGRAMS.

"Computer programs and procedures shall be provided to verify that the trainer is operationally ready for training. These programs and procedures shall test the operational readiness of all major component subsystem equipment which operates under computer control. The programs shall generate outputs to all instruments, controls, lights, and equipment whose operation can be verified with a visual or aural check. The sequence of outputs shall be cyclic, with provisions to stop the sequence at any point. These programs are not intended as calibration programs, but rather as quick system operational checks, and are normally run on a daily basis before the start of the day's training. The time required to complete the operational readiness procedures shall not exceed ________________."

Rationale and Guidance: This requirement is necessary in order to prevent the waste of valuable training time due to a trainer failure which might exist prior to the commencement of a training session. If a fault is observed with these procedures that might adversely affect the training mission, repairs can be effected and the training session rescheduled. Since it is a "system" requirement covering all major component subsystems, it must appear in this section of the specification.

Performance Parameters: A reasonable time limit must be selected for the completion of these tests and procedures. The suggested value for this parameter is "15 minutes."

Background and Sources: None available.

Lessons Learned:

3.7.2.1.2.3 CPS DOCUMENTATION.

"Documentation shall be provided for the CPS to support its operation, mission support activities, modification support activities, update and revision. Commercially available documentation shall be provided for all unmodified commercial off-the-shelf computer programs and computer program packages used in the CPS. This documentation shall include (as available) programming language manuals, user manuals, maintenance programming manuals, system programming manuals, etc. In addition, all CPS elements shall be documented as specified elsewhere in this specification."

Rationale and Guidance: As with 3.7.2.1.1.2, this paragraph is an extension to the next lower level of the "system" requirement for documentation of the Computational System stated in 3.7.2.1.

Performance Parameters: No modification of this paragraph is required. However, the requirement for commercial documentation for commercial computer programs must be consistent with the SOW and CDRL (and vice versa). Requirements for documentation for newly developed and modified computer programs will be stated in the Computational Subsystem section (and other subsystem sections specifying their own unique computational resources) of this specification.

Background and Sources: None available.

Lessons Learned:

3.7.2.2 COMPUTATIONAL SUBSYSTEM CAPABILITIES.

"Unless otherwise explicitly specified, all computational resources employed in the trainer (including embedded processors, firmware, etc.) shall be subject to the requirements of the Computational Subsystem as specified in the following subparagraphs."

Rationale and Guidance: As an introductory paragraph for the Computational Subsystem, this paragraph establishes the scope of the Computational Subsystem.

Performance Parameters: The use of unmodified actual aircraft equipment such as on-board computers may warrant a waiver to requirements of this section. This should be investigated with respect to advantages/disadvantages for each individual case. The advent of embedded training, more on-board computers, and modular hardware design may present new concerns and may justify waiving all or some of these requirements.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1 COMPUTATIONAL SUBSYSTEM HARDWARE.

"The trainer Computational Subsystem hardware configuration shall fulfill the requirements stated in 3.7.2.1 and elsewhere in this specification and include the equipment specified. This hardware shall satisfy the main computational requirements for all functional subsystems except ______________________."

Rationale and Guidance: This paragraph is a lead-in to the section of the specification in which detailed requirements for the Computational Subsystem hardware will be stated.

Performance Parameters: List here the subsystems for which separate computational hardware is specified. If there are none, then delete the word "except" and end the sentence there. It is recommended that the requirements in this section be levied on all computational hardware throughout the trainer and that only functional computational requirements be levied by the other functional subsystem activities. Then, no exception need be made. Nothing else need be included here unless special conditions warrant a general requirement which applies to all Computational Subsystem hardware.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.1 COMPUTATIONAL EQUIPMENT PERFORMANCE CHARACTERISTICS.

"Each computer configuration in the trainer Computational Subsystem shall satisfy the performance requirements and possess the characteristics specified herein."

Rationale and Guidance: This paragraph serves as an introductory paragraph to those paragraphs which specify performance characteristics and requirements for computational equipment in the Computational Subsystem.

Performance and Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.1.1 COMPUTATIONAL REQUIREMENTS.

> "In order to meet the programming language requirements (specified in 3.7.2.1), each processing unit (Central Process Unit or Auxiliary Processing Unit, mini or micro) shall be capable of performing single- precision and double-precision floating-point arithmetic at rates sufficient to satisfy all computational requirements (both real-time and background processing)."

Rationale and Guidance: The objective of this paragraph is to assure that the computational speed of the processing units will be considered as a design or selection factor for the Computational Subsystem hardware. This also ties in with the programming languages which specify single- and double-precision floating-point data types.

Performance Parameters: Waivers of this requirement may be granted for specific computer resources in the Computational Subsystem which do not have stringent floating-point arithmetic requirements. In such cases, the contractor will be forced to justify the request for the waiver by providing a thorough analysis of the computational throughput requirements for the specific computer equipment to which the waiver applies.

Background and Sources: None available.

Lessons Learned: In the past, a thorough analysis of the computational throughput requirements for a maintenance trainer has rarely been done. The result of this has been that during the middle of full-scale development, the design of the maintenance trainer is changed by adding one or more additional processors. This is costly to the Government in more ways than is initially apparent. First, there are the obvious additional hardware costs and redesign costs. Second, the schedule to complete the trainer is lengthened. Third, changes in the middle of a development effort tend to be "patch-up" jobs, which have an effect upon the reliability and maintainability of the resulting product. Thus, it is important to establish early in the design process that the contractor has a sound approach to assure this requirement is satisfied. Ideally, the contractor should identify the method used to assure that the configuration of computational hardware will meet this requirement during the proposal evaluation phase, prior to contract award.

3.7.2.2.1.1.2 INTERRUPT PROVISIONS.

"Each computer configuration in the Computational Subsystem shall include a priority interrupt system to support the real-time, event-driven nature of the training device. This system shall (1) provide hardware to distinguish between and identify the sources of simultaneous hardware-generated interrupts, queuing them for service depending on their priorities, and (2) allow computer-program-generated interrupts (e.g., supervisor calls). An interrupt (hardware- or computer-program-generated) shall cause the execution of an interrupt service routine unique to the device or function to which the interrupt pertains."

Rationale and Guidance: This requirement is intended to ensure that the contractor will understand the real-time nature of external inputs to the training device (control inputs, etc.) and will provide a feasible means to support the real-time requirements.

Performance Parameters: Maintenance trainers may or may not require real-time operation. If not, then this paragraph may be deleted from the specification.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.1.3 INTERVAL TIMING PROVISIONS.

"Each computer configuration in the Computational Subsystem shall include at least one programmable interval timer accessible to each processing unit in the configuration. The interval timers shall be capable of generating both periodic (repetitive) and one-shot (single-occurrence) interrupts. Each interval timer shall be settable and readable under program control, and shall provide interrupts to its processing unit with a resolution of at least ____ ______."

Rationale and Guidance: Interval timing provisions provide the capability to sample external inputs and to perform iterative computations at regular intervals. This is required in a real-time simulated environment.

Performance Parameters: Replace this blank with an appropriate value (usually expressed in milliseconds). The value selected should be at least twice as short as the period of the maximum

iteration rate or sampling rate. For example, if the maximum iteration rate is 30 Hz, then the value would be 1/60 second or 16 milliseconds. See also 3.7.2.2.1.1.2.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.1.4 REAL-TIME CLOCK.

"One or more real-time clocks shall be accessible to each processing unit in the Computational Subsystem to provide operational timing functions. Each real-time clock shall have a range which includes the Julian date and time of day with a resolution of at least ______________________________. All real-time clocks (if more than one is used) shall be synchronized with one another such that they all reflect the same values."

Rationale and Guidance: A real-time clock is a function which is needed to provide timing information such as mission durations, logs, etc. This function may be implemented with hardware or software (in conjunction with interval timing provisions).

Performance Parameters: The minimum resolution for the real-time clock must be specified here. This value is usually 1 second, which is the maximum amount which should be specified. (See also 3.7.2.2.1.1.2).

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.1.5 BOOTSTRAP LOADING PROVISIONS.

"The Computational Subsystem shall include a hardware bootstrap for loading from the mass storage equipment specified herein (3.7.2.2.1.4.1). The implementation of this requirement shall be consistent with the requirement for separate loading, initialization, and reinitialization of each computer configuration (3.7.2.1.1.1)."

Rationale and Guidance: This requirement is stated to assure that the process for "bringing up" the system will not require a lengthy manual process which would waste valuable training time.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.1.6 POWER FAILURE HARDWARE.

"Each computer configuration shall include hardware to provide the power fail capabilities specified herein (3.7.2.2.2.1.1). The hardware shall be designed to prevent damage to the Computational Subsystem in the event of a power failure, surge, or reduction."

Rationale and Guidance: Power failure hardware is necessary to ensure that the trainer Computational Subsystem hardware will suffer no damage and that the integrity of the Computational Subsystem computer programs as stored in mass storage will not be compromised as the result of a power failure.

Performance Parameters: In some complex trainers, it may be desirable to expand the power-fail capability to include battery backup of all volatile storage technologies used so that training may resume from the point at which it stopped when the power is restored. With multiprocessor configurations and the expanded use of microprocessors, the addition of battery backup may be impractical. The system computational design must be evaluated to determine the usefulness and cost effectiveness on a system level.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.2 INPUT/OUTPUT HARDWARE.

"The trainer Computational Subsystem shall be provided with an input/output (I/O) capability sufficient to satisfy all I/O requirements of the computer programs executing upon it. The I/O hardware shall include but not be limited to any computer vendor standard input/-/output boards and chassis installed in each computer configuration. In addition, spare I/O capacity shall be provided as specified herein (3.7.2.2.1.5.3)."

Rationale and Guidance: The I/O hardware is defined in this paragraph to consist of "any computer vendor standard I/O boards and chassis installed in the Computational Subsystem." The key word here is "standard." It provides a means to distinguish

between the I/O hardware and interface hardware. The I/O hardware can be considered as part of each computer configuration. Devices are connected to the I/O hardware using interface hardware (e.g., linkage) when necessary. It is essential to define the I/O hardware as being separate from the interface hardware because spare capacities for both are defined separately.

Performance Parameters: No input from the preparer is required.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.3 INTERFACE HARDWARE.

"Interface hardware (e.g., linkage) shall be provided as necessary to interface the I/O hardware to other trainer hardware controlled by the Computational Subsystem. The interface hardware shall include (but not be limited to) the following types of data conversion hardware which are used in the trainer: ____________________

____
In addition, spare interface hardware shall be provided as specified in 3.7.2.2.1.5.4 herein."

Rationale and Guidance: Interface hardware is that specialized hardware which is used to connect the I/O hardware to a device. The various types of interface hardware which may be found in a maintenance trainer are listed here and are formally defined to be interface hardware.

Performance Parameters: The list of hardware types should include the following:

- analog-to-digital input
- digital-to-analog output
- discrete-to-digital input
- digital-to-discrete output
- digital (parallel and serial) input and output
- digital-to-synchro output
- special purpose interface hardware (e.g., avionics bus interface).

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.4 PERIPHERAL EQUIPMENT.

"Peripheral equipment shall be provided as specified in the following subparagraphs and functional subsystem sections (as required) of this specification. This equipment shall be sharable (program control switchable) among the Computational Subsystem computer configurations as required by this specification. All peripheral equipment shall be taken into account (i.e., I/O requirements shall be established) for the verification of required spare capabilities (e.g., spare I/O capacity)."

Rationale and Guidance: This paragraph is a lead-in paragraph to the detailed requirements for peripheral and auxiliary equipment.

Performance Parameters: The types and amount of peripheral equipment specified will be dictated by the supporting command's support plan and the using command's functional requirements (e.g., lesson generation, record/playback).

Background and Sources: See AFHRL-TP-84-49, paragraph 2.1.2.11, for information on logistics factors associated with peripheral equipment.

Lessons Learned:

3.7.2.2.1.4.1 MASS STORAGE EQUIPMENT.

"Mass storage equipment shall be provided as specified in the following subparagraphs. The capability shall be provided to copy between units of different types of mass storage. The mass storage equipment shall be sharable between the computer configurations in the Computational Subsystem which require access to mass storage devices."

Rationale and Guidance: Mass storage equipment is required: (1) to store CPS computer programs and data (used by the Computational Subsystem) while the trainer is not operating, (2) to provide a media which can be used to deliver updates and modifications to the CPS, and (3) to access the real-time data bases (i.e., visual) which are needed and which are too large to be resident in memory.

Performance Parameters: The requirement for a "capability...to copy between units of different types of mass storage" is dependent upon the support and operational requirements of the particular training device because these will dictate what different types of mass storage are needed. A trainer which requires high-speed access to real-time databases will most likely

incorporate rigid magnetic disk mass storage equipment to satisfy this requirement. However, since a magnetic disk is not a convenient medium on which to deliver updates and modifications, another secondary mass storage technology such as magnetic tape or flexible (floppy) disk would also be selected. This would mandate the copy requirement. On the other hand, a trainer which does not require real-time access to databases may not need a magnetic disk storage system. Then the copy requirement would not apply.

It should also be noted that the use of "exotic" storage technologies is not desirable unless it has definite proven advantages in cost or performance (keeping supportability and life cycle cost in mind).

Additional requirements may be stated here if they apply to all types of mass storage equipment selected. These additional requirements would be trainer-unique.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.4.1.1 PRIMARY MASS STORAGE.

> "Mass storage equipment shall be provided and used for storing and loading the operational CPS and for on-line, real-time, and non-real-time data access. The type, size, and complexity of the equipment shall be a function of the Computational Subsystem design, operational load size, and the total system requirements for on-line, real-time and non-real-time information flow and timing."

Rationale and Guidance: Primary mass storage equipment is required to satisfy requirements (1) and (3) defined in the rationale for 3.7.2.2.1.4.1.

Performance Parameters: Identify any additional requirements for primary mass storage which are trainer-unique. Minimum mass storage requirements for well-defined digital databases (e.g., Defense Mapping Agency (DMA) Digital Landmass System (DLMS) Data Base) may be added to this paragraph. Parameters such as size, format, record-size, etc. may be specified if justified.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.4.1.2 SECONDARY MASS STORAGE.

> "Industry-compatible mass storage equipment shall be provided as secondary mass storage. The equipment shall be used to install CPS changes which are distributed on media transported from the trainer support activities or computer vendors. Selection criteria for secondary mass storage shall include media portability, special support requirements (e.g., media shelf life for archiving data, classified data protection, data transfer rate requirements, data base sizes, etc.), reliability, and maintainability. The unit(s) provided to satisfy the "transport media" requirement shall be accessible (i.e., electrically switchable as a minimum) among all computer configurations in the Computational Subsystem. In the event one type of secondary mass storage is not compatible with all computer configurations, another compatible type shall be provided. If all requirements for secondary mass storage are satisfied by the primary mass storage equipment selected, then no additional equipment need be provided."

Rationale and Guidance: Secondary mass storage is required to satisfy requirement (2) defined in the rationale for 3.7.2.2.1.4.1.

Performance Parameters: In order for the contractor to make the best decision as to the type and quantity of secondary mass storage equipment, these parameters are not specified. However, a list of equipment types from which the contractor may choose could be included here if desired. Such a list should also allow the contractor to recommend an alternate type of equipment which is not listed. The purpose of this approach is to assist the contractor in consolidating the secondary mass storage requirements with any other storage media requirements.

Background and Sources: None available.

Lessons Learned: Magnetic tape equipment is generally the preferred choice for secondary mass storage since most minicomputer and large mainframe computer vendors provide software support on magnetic tape. In the past, devices such as magnetic tape or floppy disk have been explicitly specified in the spec to fulfill the functional requirements identified. This has resulted in perhaps less-than-optimal choices being made for secondary mass storage just to meet the spec. By not explicitly specifying the type of equipment here, the contractor may make the most cost-effective or efficient choice. However, the contractor's choice of equipment should be finalized by the time of the preliminary design review.

3.7.2.2.1.4.2 USER INTERFACE EQUIPMENT.

"User interface equipment shall be provided as specified in the following subparagraphs."

Rationale and Guidance: User interface equipment is required to allow flexible control and support of the Computational Subsystem. The users referred to by this paragraph are the operators, instructors, hardware and software maintenance personnel who need access to the system through other than simulated equipment (i.e., non-students).

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.4.2.1 OPERATOR CONSOLES.

"One or more operator consoles shall be provided to facilitate operator interaction with the Computational Subsystem. The operator console(s) shall be the primary communication device(s) for the control of the Computational Subsystem. The number and placement of the consoles shall be a function of the Computational Subsystem complexity. The operator console(s) shall satisfy the following requirements: ______________________________ ______________________________."

Rationale and Guidance: It is necessary to have one central point from which the entire Computational Subsystem can be accessed and controlled.

Performance Parameters: Specify the minimum requirements that the operator console(s) must satisfy. Requirements such as built-in hardcopy capability (i.e., teletypewriter), data transfer rates, and amounts of data to be displayed at one time should be listed here. If a combination instructor/operator console is required, then this paragraph should be deleted and the requirements should be incorporated into a single paragraph in section 3.7.3 of the specification.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.4.2.2 SUPPORT CONSOLES.

"One or more support consoles shall be provided to facilitate interface with all trainer support functions requiring the use of Computational Subsystem resources. The types, quantity, and placement of the consoles shall be a function of the Computational Subsystem complexity, the need for concurrent support activity, and all other support requirements."

Rationale and Guidance: Support consoles are required to satisfy the support requirements of the trainer. The requirements for support consoles will be based on functional requirements levied by the individual subsystems requiring support activities. This paragraph consolidates those requirements and allows the contractor to make the best possible choice in distributing the functional requirements across the consoles.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.4.3 HARDCOPY EQUIPMENT.

"Equipment shall be provided to produce hardcopy output of all data which are displayable on any peripheral display equipment controlled by the Computational Subsystem (i.e., if a graphics console is included in the deliverable peripheral equipment, then a graphics hardcopy capability shall be provided). The selection of hardcopy equipment shall be based on hardcopy throughput requirements (taking into account the number of functions which may require hardcopy capability concurrently), reliability, maintainability, supportability (non-standard hardcopy media such as thermal paper or photo-sensitized paper is not desirable), and life cycle cost. The hardcopy equipment, interface, and computer program(s) driving the equipment shall not introduce any perceptible delays in the operation of any other equipment, subsystems, subsystem features or functions of the trainer."

Rationale and Guidance: Hardcopy capability is necessary to provide student feedback, system operation documentation, maintenance information and records, and to enhance the versatility and adaptability of the trainer.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: A previous trainer was acquired with a graphical instructor console. Hardcopy capability for this console was provided by the line printer (which was a dot-matrix-type printer with graphics capability). The problem was that whenever the instructor selected the hardcopy option for a particular display, the console display "froze" for 15 seconds while the display memory was downloaded into the computer memory for spooling to the printer. The solution chosen by the instructors to this problem was to not utilize this "feature" of the instructional system. Thus, a capability was paid for which was never utilized—surely not cost effective. This prompted the current requirement for the hardcopy equipment or implementation thereof to not introduce any perceptible delays.

3.7.2.2.1.4.4 ADDITIONAL PERIPHERAL EQUIPMENT.

> "In addition to the peripheral equipment specified in the above paragraphs and any other sections of this specification, any additional peripheral equipment necessary to operate or support the trainer shall also be provided. Peripheral equipment not required explicitly by this specification but required to operate or support the trainer shall also be taken into account for the verification of required spare capacities."

Rationale and Guidance: This paragraph exists to assure that any and all peripheral equipment used to operate or support the trainer will be provided and included in spare capacity considerations.

Performance Parameters: Subsystem-unique peripheral equipment should be identified in paragraphs within each functional subsystem section of the specification. It is the responsibility of the functional engineers in charge of those subsystems to assure compliance and compatibility with the requirements of this whole section of the specification.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.5 COMPUTATIONAL SUBSYSTEM SPARE CAPACITY AND GROWTH CAPABILITY.

"Each computer configuration in the Computational Subsystem hardware shall provide spare capacities as specified in the following subparagraphs. The capability shall be provided to verify the spare capacities specified. In addition, the Computational Subsystem shall be expandable in a fashion that does not cause existing equipment to become obsolete."

Rationale and Guidance: Spare capacities and a capacity for system growth are necessary to ensure that the system will have the ability to adapt to changes which are related to factors such as:

1. Changing mission requirements.
2. Equipment upgrades and modifications.

They are also necessary to avoid overloading the system such that it performs inefficiently.

Performance Parameters: Specify any general spare capacity or growth capability requirements for the computer configurations in the Computational Subsystem as applicable.

Background and Sources: See AFHRL-TP-84-49, paragraphs 2.6.2.8, 2.7.2.2, and 2.7.2.3, for information related to logistics factors associated with modification support and spare capacity.

Lessons Learned:

3.7.2.2.1.5.1 SPARE PROCESSING TIME.

"Spare processing time shall be provided. The spare processing time requirement shall apply separately to each processing unit (i.e., CPU and APU) in each computer configuration. A frame shall consist of a fixed scheduling of synchronous computer program components. The duration of each frame (available frame time) shall not exceed the period (1/f) of the maximum computer program component iteration rate. The processing time associated with a frame shall include processing time dedicated to background processing used in the normal support of the trainer and shall take into account memory bus connections between processors and I/O equipment performing direct memory access."

"a. As a minimum, ______________________ percent of the available frame time shall be provided as spare processing time to provide a buffer between the worst-case (maximum) frame execution time and a frame overrun (when the execution time for a frame exceeds the available frame time). The worst-case frame time shall be the maximum frame time observed with the trainer operating under heavily loaded conditions (i.e., all concurrent support activities operational and the maximum level of simulation being performed)."

"b. In addition, __________________ percent of the available frame time shall be provided as spare processing time to allow for changing mission requirements over the life cycle of the trainer."

"c. Therefore, a total of __________________ percent of the available frame time shall be provided as spare processing time. This total spare is the spare which shall be verified."

Rationale and Guidance: (see 3.7.2.2.1.5)

Performance Parameters (Item a): The recommended value is five percent, although a higher value may be selected if it is envisioned that the requirement may be difficult to verify accurately (due to the complexity of the trainer).

(Item b): The recommended value is 25 percent, but much higher levels (up to 50 percent) may be justified if mission requirements are expected to undergo extensive change or increase.

(Item c): Replace this blank with the total of (a) and (b).

For maintenance trainers which have no real-time processing requirements, this paragraph may be deleted.

Background and Sources: None available.

Lessons Learned: This is a real problem area! The two main concerns are:

(1) The inability of the procuring activity to accurately determine what the actual spare processing time NEEDS of a program will be.

(2) The difficulty of verifying that the spare requirements specified are indeed met.

The difficulty of determining spare processing time needs stems from the fact that no two programs are alike. Differences in computer configurations and software coding practices make it impossible to determine in advance just how much spare is needed to implement the ESTIMATED number of modifications and mission enhancements envisioned for the program. For example, if two different programmers are assigned to implement a software change, one programmer's implementation may take twice as much processing time as the other's. The best advice is to research previous trainer acquisitions, noting (1) the point in the actual equipment's life cycle at which the trainer acquisition commenced and when it was delivered, (2) the specified spare time requirement, (3) the spare time achieved, and (4) how much of the spare has been used for modification/enhancements since the trainer became operational, then make a reasonable (?) guess. A general rule-of-thumb is:

percent spare processing time =
percent of actual equipment life cycle left / 2.

This is based upon the projected delivery date of the trainer; e.g., for a trainer delivered 4 years into the life cycle of an airplane with an expected life of 20 years the specified percent spare would be:

$$(((20 - 4) / 20) \times 100\%) / 2 = 40\%).$$

Keep in mind that the buffer spare for frame overruns is always required no matter how far along in the device's life cycle. A possibility in future trainers is a highly modular, distributed processing configuration in which processing power may be added incrementally without affecting the total operation of the processing system. In such a configuration (if truly modular), very little (if any) spare processing time would need to be specified in some of the subsystems. However, expansion capability should be specified in its place.

Verification of spare processing time has caused many headaches in the past. Trainers have been designed with "floating" frame scheduling, variable frame lengths, variable iteration rates, and other methods of computer program control which have made it very difficult to measure spare time. This has prompted the more explicit definition of a frame and the requirement that it be "fixed"; i.e., starting and finishing at predictable, fixed times within each cycle. A contractor who objects to this requirements may have good reasons, and exceptions to this requirement may be granted under certain conditions. The basic requirement is that spare time must be accurately measurable. If the contractor can demonstrate that this basic requirement can be met, the fixed scheduling requirement can be waived. This requirement can also

be waived if the contractor proposes a highly modular distributed processing configuration for which the spare processing time requirement has also been reduced significantly.

3.7.2.2.1.5.2 SPARE MEMORY OR MEMORY EXPANSION CAPABILITY.

> "_________________ percent usable spare memory or memory expansion capability shall be provided to allow for changing lesson requirements over the life cycle of the trainer. This requirement shall apply separately to each type of memory (static, dynamic, etc.) in each computer configuration, and also to both common and private memory. The decision to provide spare, expansion capability, or a combination of both shall be based on life cycle cost (to the best extent possible)."

Rationale and Guidance: (See 3.7.2.2.1.5)

Performance Parameters: Specify the minimum amount of spare or expansion memory to be provided or allowed for as a percentage of the total amount of memory provided. The recommended amount is 25 percent, although as with spare processing time, this amount may be greatly increased (up to 50 percent) or decreased, depending upon the envisioned changes to mission requirements. The value selected should correlate closely with parameter (b) in the spare processing time requirement.

Background and Sources: None available.

Lessons Learned: As with spare processing time requirements, the number specified is equally hard to determine. (See 3.7.2.2.1.5.1 Lessons Learned.)

3.7.2.2.1.5.3 INPUT/OUTPUT EXPANSION.

> "The total number of I/O channels in each computer configuration shall be increasable by ______________ percent (i.e., spare slots for I/O boards shall be provided). The available information transfer capacity shall be increasable by the same percentage without degrading the performance of the trainer. The inclusion of spare I/O channels with the trainer (or a combination of spare and expansion) is allowable if it is more cost effective over the life cycle of the trainer. However, the spare I/O channels must be evenly distributed across all computer configurations and I/O channel types."

Rationale and Guidance: (See 3.7.2.2.1.5)

Performance Parameters: The recommended value for this parameter is 50 percent. This requirement is intended to allow for mission enhancements and modifications. If little change is envisioned, this requirement may be relaxed significantly or eliminated.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.5.4 INTERFACE HARDWARE SPARE CAPACITY.

"____________ percent of each type of interface hardware shall be provided as spare. This spare interface hardware shall be usable without degrading the performance of the trainer (i.e., the Computational Subsystem shall be capable of driving both the used and spare interface hardware at their fully loaded capacities). The spare capacity shall be evenly distributed across each interface hardware type and shall be easily accessible to any computer configuration in the Computational Subsystem."

Rationale and Guidance: (See 3.7.2.2.1.5)

Performance Parameters: The value selected for this parameter should correlate with the spare I/O capacity selected in the previous paragraph. It would not make sense to have more spare interface hardware than there is capability to drive it. (See 3.7.2.2.1.5.3.)

Background and Sources: None available.

Lessons Learned: The reason spare hardware is specified rather than expansion is that the interface hardware is usually not standard computer vendor hardware. This hardware may be hard to procure as spare parts.

3.7.2.2.1.5.5 PRIMARY MASS STORAGE SPARE AND GROWTH.

"a. Each unit of primary mass storage equipment shall have an on-line, spare storage capacity that is at least _______ percent of its total capacity."

"b. The on-line storage capacity provided for primary mass storage shall be increasable by ________ percent (i.e., the addition of units shall be provided for)."

Rationale and Guidance: (See 3.7.2.2.1.5)

Performance Parameters (Item a): Specify the minimum acceptable spare capacity for primary mass storage. The recommended value is 50 percent of its allocated capacity.

(Item b): Specify the growth capability required for primary mass storage. The recommended value is 100 percent (i.e., expansion from one unit to two, or at least the addition of one more entire unit of mass storage equipment).

For trainers with little or no lesson enhancement/modification requirements, the growth capability requirement may be eliminated. However, it is good practice to maintain a minimum amount of spare capacity for mass storage.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.1.5.6 PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS.

> "The Computational Subsystem shall operate within the total trainer requirements, in accordance with the environmental characteristics of this specification. The Computational Subsystem shall operate with the power available at the installation site. Means shall be provided to eliminate transients, pulses, and other electrical noise that could cause Computational Subsystem malfunctions."

Rationale and Guidance: The Computational Subsystem should not create any special power supply requirements at the installation site but should be protected against damage from electrical hazards and power fluctuations.

Performance Parameters: This paragraph may not be needed if there is a system-level requirement which contains the same information.

Lessons Learned: On one simulator studied, inadequate air conditioning and humidity had caused the corrosion of circuitry.[7] Environmental characteristics should be specified in the design process in order to ensure that the maintenance trainer will be designed to work in its expected environment.

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[7]Carroll, R. J., Thocher, L. I., Roth, J. T., & Massey, R. H. Maintenance training simulators: Their use, cost, and perceived effectiveness. AFHRL-TR-84-53. Lowry Air Force Base, Colorado: Training Systems Division. 1985.

3.7.2.2.2 COMPUTATIONAL SUBSYSTEM COMPUTER PROGRAMS/DATA.

> "Computer programs/data shall be provided for the Computational Subsystem which support all modes of trainer operation (i.e., training, student evaluation, support, and maintenance and test). These programs shall perform all computations and input/output functions at rates sufficient to satisfy all requirements in this specification. Commercially available computer programs/data shall be used to satisfy these requirements wherever possible. A standard computer vendor operating system shall be provided and used in each general-purpose digital computer in the Computational Subsystem during all modes of trainer operation. The operating system (OS) configuration used while training is in progress shall provide for the concurrent execution of background computer programs. This OS (and all configurations thereof) shall be at the latest vendor revision level."

Rationale and Guidance: This paragraph identifies requirements unique to the Computational Subsystem elements of the CPS. The vendor operating system (OS) requirement is to minimize life-cycle support problems due to revision changes to the vendor equipment or software. For this reason, a vendor OS is required for all trainer operating modes. The paragraph also requires that the OS used during training must support execution of "background" computer programs. The purpose of this requirement is to assure maximum utilization of the Computational Subsystem for on-site operational support (mission support and maintenance). This capability will provide for executing computer programs for activities such as mission scripting (lesson plan development), student performance evaluation, radio/navigational aids modification, etc., while training is being conducted, in preparation for the next or future training sessions.

Performance Parameters: The requirements of this paragraph should not require changes to account for different computational architectures. If no general-purpose digital computers are utilized, then the vendor OS requirement will not apply and some other provisions will have to be made.

Background and Sources: None available.

Lessons Learned: Maintenance trainers have been procured which utilized contractor-developed run-time systems (RTSs). Computer programs were developed and compiled on standard vendor OS-based systems and down loaded to the contractor's RTS-based hardware. The problems encountered as a result were many. In one case, with

the normal maintenance of the computer hardware, revisions were incorporated which affected the functioning of the RTS. This forced a revision to the RTS, the cost of which was borne by the Government. In another case, it was decided not to incorporate vendor hardware revisions as they were issued, with the intent that this would solve the contractor RTS problem, but it created another. It was discovered that, over time, replacement parts for the computer equipment would not operate on the trainer hardware because the replacement part design assumed that the computer hardware had been maintained at the latest vendor revision level. This severely impacted the supportability of the trainer. As a final example, in a multi-unit trainer acquisition, the pre-production unit (PPU) software was developed with a FORTRAN-66 compiler on a vendor OS-based system and executed on a contractor-developed RTS. In the time period between the delivery of the PPU and the first production unit, the new FORTRAN-77 standard compiler had been accepted. The SOW for the trainer acquisition stated that all units delivered must utilize the latest version of the compiler available. But programs compiled with the new compiler would not execute within the RTS environment, thus forcing a revision of the RTS. These types of problems prompted the requirement for the use of a vendor OS during all modes of trainer operation and for the incorporation of all OS revisions as they are released.

The requirement for "background" processing was a result of the constantly increasing computational requirements of trainer support activities. Several newer trainers were delivered with sophisticated training systems incorporating a great deal of flexibility. This flexibility was provided through alteration of the "simulated environment" using software which produced the desired "new environment." The problem with these systems was the fact that no provision had been made to reduce the availability of the trainer so that the "environment alteration" software could be run, and no additional computational equipment was available for that purpose. This has resulted in one of two situations:

1. If the "environment alteration" was absolutely necessary in order to satisfy trainer mission requirements, then the planned utilization or availability of the trainer had to be reduced, affecting the entire training program.

2. If the "environment alteration" capability was NOT absolutely required to satisfy trainer mission requirements, then the capability was not utilized (in other words, it was a waste of money to have acquired the capability).

3.7.2.2.2.1 SUPERVISOR/EXECUTIVE COMPUTER PROGRAM.

> "Computer programs shall be designed and provided which shall maintain and direct the problem flow and establish priority controls over all trainer operational computer programs/data. These programs shall provide all functions necessary to control the multiple iteration rate task structure and shall provide frame and cycle synchronization, at fixed rates and durations, such that spare processing time can be measured."

Rationale and Guidance: This paragraph establishes the basic requirements for the software which controls the execution of real-time trainer functional software on the Computational Subsystem.

Performance Parameters: The requirements of this paragraph should not need modification. The requirements for synchronization are general and do not specify centralized executive or inhibit a distributed executive. The key requirement is for the executive to activate the software in a structured and "fixed" scheduling such that spare processing time can be measured and utilized for expansion. (See 3.7.2.2.1.5.1 Lessons Learned.) If the trainer does not require real-time operation, then this requirement may be deleted.

Background and Sources: None available.

Lessons Learned: A past trainer utilized an executive/supervisor which incorporated a "floating-frame" scheduling technique. This technique allowed frame start times to "float" within "time-windows" of a certain iteration rate as opposed to occurring at fixed times relative to the other iteration rates. Several problems resulted from this approach:

1. The timing of processing of the different iteration rates relative to each other was not consistent or sufficiently stable, and caused wholesale trainer performance degradation under loaded conditions.

2. Spare processing time could not be measured or calculated accurately. Also, the spare provided was not usable to provide for expansion of processing at all iteration rates without restructuring and resequencing of the CPCs in the entire real-time software structure.

Therefore, any changes required redevelopment and large-scale (if not complete) retesting of all trainer performance parameters.

3.7.2.2.2.1.1 POWER FAILURE COMPUTER PROGRAMS.

"Computer programs/data shall be developed to provide for the orderly shutdown and restart of the Computational Subsystem in the event of trainer power loss, reduction, or interruption. The programs shall cause the status of the trainer to be saved on a mass storage device. The status saved shall include all data and other parameters (i.e., registers, stacks, tables, etc.) necessary to restore the configuration of the Computational Subsystem and associated trainer hardware to the configuration which existed within _________________________ seconds or for the lesson step (whichever is applicable). These programs shall operate with the power failure hardware provided." .

Rationale and Guidance: Power failure capacity, independent of the complexity, is necessarily made up of the hardware and operating system interrupt handler (software). This paragraph identifies the basic software requirements for this capability and is tied to the hardware requirements in the previous section.

Performance Parameter: The requirements stated are those which are appropriate for most maintenance trainers. However, in some large, complex maintenance trainers, there may not be enough time to save the complete status of the trainer during the period between the detection of power failure and complete system shutdown. Then a battery backup capability for all volatile storage (i.e., memory) may be specified in 3.7.2.2.1.1.6. For simple trainers, this requirement may not be cost effective or practical. For more complex trainers, a mass storage device may be used to store sampled data at certain time intervals (for a real-time or free-play trainer). A suggested value would be 10-second intervals. For procedural training approaches, each step of the lesson could prompt a sampling of state information.

Background and Sources: None available.

Lessons Learned: In a recent study, it was discovered that, for one maintenance training simulator, recent cassette memory was erased as the result of power failure. Although the damage was not extensive, even a minimal loss is noteworthy.

In the same study, several instructors surveyed noted that the capability of the computers to be restarted without having to be reinitialized was a favorable feature of the computer systems.[8]

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[8]Carroll, R. J., Thocher, L. I., Roth, J. T., & Massey, R. H. Maintenance training simulators: Their use, cost, and perceived effectiveness. AFHRL-TR-84-53. Lowry Air Force Base, Colorado: Training Systems Division. 1985.

3.7.2.2.2.1.2 DEBUG COMPUTER PROGRAMS.

"Computer programs/data shall be provided to assist maintenance personnel in debugging CPS computer programs and Computational Subsystem hardware. These programs shall operate in real time during normal trainer operation. User interaction with these programs shall occur through a support console. These programs shall satisfy the following requirements: ____ ____."

Rationale and Guidance: This paragraph requires the functional characteristics of what used to be the "Digital Remote-control Unit" (DRU). The DRU was a handheld I/O device used to debug and monitor the performance of the trainer by using read and write capabilities into the computer CPU and memory.

Performance Parameters: The functional needs of the old DRU are still valid; however, the traditional approach (the unit) is no longer valid. With the advent of mapped operating systems and "user registers", many of the old functions of the DRU become meaningless or impossible to perform. The needs of a maintenance or engineering individual can still be met with a console of the contractor's choice which satisfies the same functional requirements. These requirements should include:

- The ability to examine and alter the contents of any memory location and processor register, utilizing decimal and either hexadecimal or octal address and data representation.

- The ability to monitor the contents of a minimum of 40 variable storage areas in private and common memory at a time, each of which is independently preselectable by variable name.

- The ability to enable and disable a task.

- The ability to monitor the task structure in memory (i.e., a memory map showing task allocations, etc.)

A maintenance technician should be consulted to determine the need for additional functional capabilities.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.2 INPUT/OUTPUT COMPUTER PROGRAMS.

"Computer programs/data shall be provided for control of inputs from and outputs to all peripheral equipment and interface hardware controlled by the Computational Subsystem during all modes of trainer operation."

Rationale and Guidance: This paragraph identifies the requirement for input/output software to be delivered. This requirement covers all elements of the Computational Subsystem-- both vendor- and contractor-developed hardware.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.3 COMPUTATIONAL SUBSYSTEM MISSION SUPPORT COMPUTER PROGRAMS/DATA.

"Computer programs/data shall be provided to support the total on-line and off-line operational requirements of the trainer. All programs provided shall satisfy the general requirements for support programs specified in 3.7.2.1.2.2.1."

Rationale and Guidance: This paragraph identifies the applicable requirements for Computational Subsystem mission support programs as required by 3.7.2.1.2.2.1 for all major component subsystems.

Performance Parameters: The requirements stated here are generic in nature and basically identify the specifics that follow. No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: The requirement for the vendor operating system (specified in paragraph 3.7.2.2.2) is very important. Since the Computational Subsystem and other major component subsystems of the trainer are likely to have support requirements which are accomplished by a remote support activity, there must exist a method to transport data and software between the support site and the trainer(s). The vendor operating system forms the foundation of that capability, along with the other support programs specified herein. Where functional requirements are stated in the following subparagraphs which should or might also be required at a remote or stand-alone Trainer Support Subsystem (TSS), then the specification paragraphs should state that the required capability shall be compatible with the TSS.

3.7.2.2.2.3.1 MASS STORAGE COPY/COMPARATOR PROGRAMS.

"Computer programs shall be provided which satisfy the following functional requirements between all units (e.g., drives, transports) of similar and dissimilar mass storage in both the primary and secondary mass storage systems (e.g., disk-to-disk, disk-to-tape, tape-to-tape, etc.): ____. These programs shall be operable through an operator or support console and shall allow the error output to be optionally directed to hardcopy."

Rationale and Guidance: This capability is necessary to install CPS changes from the various support activities distributed on secondary mass storage media.

Performance Parameters: The functional requirements list should include the following:

- Individual and multiple file copy/verification.
- File concentration and merge, file by file and by records within files.
- File-by-file comparison with suppressible error output for multiple errors, for all file types.

Compatibility with the identical TSS capability should be specified if a remote or stand-alone TSS is envisioned for the trainer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.3.2 COMPUTATIONAL SUBSYSTEM MISSION SUPPORT DOCUMENTATION.

"Documentation shall be provided for the mission support of the trainer Computational Subsystem. Included shall be user and/or operation manuals for all hardware in the Computational Subsystem and for all computer programs/data executing or designed to execute on Computational Subsystem hardware. Commercial-format user manuals and/or operation manuals may be provided for standard commercial products. In addition, a system user's manual (sometimes referred to as a system user's guide) shall be provided which outlines the procedures necessary for the daily operation and lesson support of the trainer

and provides references as necessary to the other user/ operation manuals."

Rationale and Guidance: Lesson support documentation is required to be able to carry out the necessary lesson support tasks.

Performance Parameters: No modification of this paragraph is required. However, the requirements of the SOW and CDRL must be consistent with the requirements stated above.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4 COMPUTATIONAL SUBSYSTEM MAINTENANCE AND TEST COMPUTER PROGRAMS.

"Computer programs/data shall be developed and provided to fully test the operation of the Computational Subsystem and associated equipment in accordance with the requirements specified herein. These programs shall be designed to execute on the deliverable computer configuration(s) and shall be controllable with a single support console. Hardcopy of the input and output parameters shall be an option at execution time."

Rationale and Guidance: The specified programs are required to assure maintainability and availability of the Computational Subsystem. This paragraph is essentially a lead and reference to the general Computational Subsystem maintainability requirements. The specific requirements stated, however, apply to all the subparagraphs that follow.

Performance Parameters: No input is required from the preparer.

Background and Sources: See AFHRL-TP-84-49, paragraph 2.1.2.5, for information on logistics factors associated with diagnostics.

Lessons Learned:

3.7.2.2.2.4.1 COMPUTER EQUIPMENT DIAGNOSTIC COMPUTER PROGRAMS.

"A complete set of diagnostic programs shall be provided to isolate equipment failures in the Computational Subsystem. Except for the portions of test that check whether or not inputs can be received from and outputs can be transmitted to the equipment in question, all diagnostics shall be fully automatic. This means that

once the user has loaded the diagnostic and set up initial conditions, the program will automatically generate error indications (if any) on the console and hardcopy device. These programs shall be capable of automatic execution as a total package and as individual diagnostic checks. The diagnostics shall check each computer configuration and its options, and all memory units, peripheral units, and input/output units. Programs shall also be included for computer equipment embedded in and dedicated to subsystem processing or any other special processors as defined herein."

Rationale and Guidance: Diagnostic programs which test the computer equipment are necessary to maintain the Computational Subsystem.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: These diagnostic programs are normally supplied by the computer vendor and are supplied to operate with a specified minimal configuration of equipment and peripherals. It is important that attention be paid to embedded computer equipment. In some applications the configuration of computer equipment may be such that standard vendor diagnostics cannot be used. In such a case, the development of diagnostic capability must be ensured.

3.7.2.2.2.4.2 INTERFACE HARDWARE DIAGNOSTIC COMPUTER PROGRAMS.

"Computer programs/data shall be provided to perform functional checkout of all trainer interface hardware controlled by the Computational Subsystem at performance rates and with test values characteristic of real-time operation. This shall include the checkout of instructor/operator station interfaces, I/O controllers, multiplexers, demultiplexers, signal conversion equipment, special interface equipment, and any other interface hardware that is functionally testable with computer programs/data. The programs shall provide fault isolation and identification to the appropriate level. Trainer equipment normally driven by this interface hardware shall be automatically disconnected during the performance of these tests when necessary to prevent equipment damage. All disconnection and reconnection shall be accomplished under computer control. The programs shall perform automatic range checking of the user inputs to prevent equipment damage caused by out-of-range values. The programs shall also perform the tests and

meet the requirements specified in the following subparagraphs for the specified types of interface hardware. Testing shall be performed in a closed-loop fashion. Upon detecting a malfunction, the programs shall automatically indicate the failing hardware on the console and in hardcopy."

Rationale and Guidance: This paragraph defines the scope and general functional requirements which apply to the following sub-paragraphs. Provided is the reference to the general maintainability requirements which drive these software requirements. Most often the software for these requirements is developed by the trainer contractor since it is specific to the design of the trainer.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4.2.1 DISCRETE INPUT AND OUTPUT TESTS.

"The interface hardware diagnostic computer programs/data shall check the proper functioning of all the discrete input and output channels, including spares, in a closed-loop fashion."

Rationale and Guidance: This paragraph identifies the scope of the tests required for discrete I/O interface hardware.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4.2.2 ANALOG INPUT AND OUTPUT TESTS.

"Analog input and output tests shall be performed which exercise all of the analog interface hardware through its full range of operation. This shall be accomplished in a closed loop fashion. The tests shall be designed such that accuracy criteria have defaults or can be overridden by the user. Tests shall include a dynamic test which enables the user to specify (on the console) the amplitude of a test signal to a specified channel.

Rationale and Guidance: This paragraph identifies the scope of the tests required for analog interface hardware. The requirement for the specified interactive capability is unique to the testing of these analog channels.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4.3 TRAINER EQUIPMENT TEST COMPUTER PROGRAMS.

> "Computer programs/data shall be provided to check the proper functioning of all remaining equipment in the trainer which is controlled by the Computational Subsystem that cannot be tested in a closed-loop fashion."

Rationale and Guidance: This paragraph identifies the requirement for test programs to be provided for equipment and subsystems which cannot be tested by the general "closed-loop" testing method used for the previously identified trainer equipment.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: Several trainers have been delivered with insufficient test and diagnostic software to maintain unique and specialized subsystem features. Equipment items such as instructor station displays, voice synthesis equipment or audio play-back equipment cannot generally be tested in a closed-loop fashion and thus little (if any) diagnostic capability was provided. An attempt to correct this situation is made by this paragraph and the requirement for all functional engineering areas to include maintenance and test software requirements in their sections of the specification (3.7.2.1.2.2.2).

3.7.2.2.2.4.4 CALIBRATION TEST COMPUTER PROGRAMS.

> "Computer programs/data shall be provided to enable all instruments and controls driven by the Computational Subsystem to be (1) calibrated and (2) tested to verify calibration. The programs shall allow both static and dynamic test signals to be applied to each instrument (as appropriate) to verify the instrument's accuracy, dynamic range, and general ability to model the performance of its real-world counterpart (e.g., lack of perceptible stepping, etc.)."

Rationale and Guidance: Calibration programs are necessary to fine-tune the trainer interface system, especially the analog I/O channels.

Performance Parameters: Care should be taken to ensure that these programs, as with all the software in this section (3.7.2.2.2.4), meet the requirements specified in the maintainability section.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4.5 SPARE CAPACITY VERIFICATION COMPUTER PROGRAMS.

> "Computer programs/data to verify the specified spare capacities (3.7.2.2.1.5) shall be provided. Optional hardcopy output shall be selectable when exercising these programs."

Rationale and Guidance: This paragraph references the requirements for spare capacities and requires computer program capabilities be provided to verify the requirements referenced. It also identifies and levies a requirement for hardcopy to be selectable when exercising each program.

Performance Parameters: No input is required from the preparer. The references provided for the spare capacities and the design requirements stated are to be applied to all the verification programs.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4.5.1 SPARE PROCESSING TIME VERIFICATION COMPUTER PROGRAMS.

> "Computer programs shall be provided and used to measure the actual frame and cycle time durations (execution times) on each computer configuration in the Computational Subsystem during the execution of the trainer operational computer programs. These programs shall be a permanent part of the real-time load and shall be selectable and deselectable without interruption of real-time trainer operation. Control of and interface with these programs shall be through a support console. The output to be computed and displayed shall include: ________________ ____."

Rationale and Guidance: An accurate means must be provided to measure spare processing time in order to verify compliance with spare requirements.

Performance Parameters: The output requirements list should include:

- The cycle number and actual cycle time duration of the longest cycle.

- The number of cycles executed and the total execution time for all cycles.

- The average cycle time duration.

- The maximum frame time duration.

- The average frame time duration.

- The cycle number and frame identification of any frame exceeding available frame time.

- The maximum and average execution times of each task (ref. 3.7.2.1.2.3) for each iteration rate, separately selectable from the items above.

Additional requirements may include a time-burner capability. If the spare processing time requirement has been modified, this paragraph should also be modified. (See 3.7.2.2.1.5.1.)

Background and Sources: None available.

Lessons Learned: In recent maintenance trainer deliveries, the trainers have been accepted with less-than-specified spare processing capacity. In all cases it has been difficult at best to determine the "usable spare" capacity. It is not simply the spare time remaining, assuming it could be measured, but rather, the amount of spare time that is usable before significant and measurable degradation of performance is apparent. This is not always the spare time calculated by the spare time verification software. In many cases it is dependent on how skillful the contractor is in designing and structuring the software so that the performance is not sensitive to loading up spare time. (Note: This is also a reason that "floating frame" scheduling (3.7.2.2.2.1) is not allowed.) If spare time is truly "usable," then using it will in no way impact the performance of the current structure of the real-time software. Therefore, the "time-burner" requirement has been developed and successfully used to determine the "usable" spare producing capacity by means of selective measures of key performance parameters, under fully loaded trainer operation, while varying the amount of time "burned" or used.

3.7.2.2.2.4.5.2 SPARE MEMORY/ON-LINE PRIMARY MASS STORAGE VERIFICATION COMPUTER PROGRAMS.

"Computer programs shall be provided to verify the spare capacities specified for memory (3.7.2.2.1.5.2) and on-line primary mass storage (3.7.2.2.1.5.5). These programs shall provide the data from which calculations will be made to verify compliance. The spare memory data shall be obtained from the trainer operational computer program configuration which produces the maximum memory utilization. Computer vendor operating system built-in functions or utilities may be used if all requirements are satisfied."

Rationale and Guidance: As with spare time, spare memory and spare on-line primary mass storage capacities must be verified. Although the requirements for verifying the specified spare capacities are just as critical as spare time, the software necessary to accomplish this is not nearly as sophisticated. The requirement is simply for software to be provided which provides the raw data necessary to do an analysis of the memory and primary mass storage loading. Most often it is accomplished by the vendor "linking" and file management facilities provided. However, in the case of newer and less sophisticated microcomputer systems, these facilities may not be inherent to the vendor software package and must be developed by the contractor.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.2.2.4.6 COMPUTATIONAL SUBSYSTEM MAINTENANCE AND TEST DOCUMENTATION.

"Documentation shall be provided to support the maintenance and test of the trainer. The documentation shall include (1) one or more test plans which outline the testing philosophy and approaches for all trainer hardware and computer programs/data, (2) a detailed set of test procedures which provide the information necessary to accomplish the operational testing of the entire trainer, and (3) maintenance manuals for all trainer hardware."

Rationale and Guidance: Documentation is necessary to carry out the maintenance and test of the trainer.

Performance Parameters: No input is required from the preparer; however, additional documentation requirements may be added or the details of the required contents may be enhanced to agree more closely with the actual documents required by the SOW and CDRL.

Background and Sources: None available.

Lessons Learned:

3.7.2.3 TRAINER SUPPORT SUBSYSTEM.

> "The Trainer Support Subsystem (TSS) shall include all hardware, computer programs/data, and documentation necessary to provide for the modification support of the trainer. The TSS shall be ____."

Rationale and Guidance: Modification support is necessary to support the trainer throughout its life cycle for changes to lesson requirements, implementation of simulation changes due to actual equipment ECPs, data base development and modification, etc.

Performance Parameters: There are two possibilities for the configuration of the TSS, depending upon the using command's support concept for the trainer. The first configuration to be addressed is that of the TSS fully integrated into an operational trainer, making use of the trainer computational resources and other trainer equipment. This configuration would be used for a training system in which each trainer site was to have the same modification support capability. In this case, the blank should be filled in with words to the effect:

> (The TSS shall be) "fully integrated into the trainer, utilizing the trainer Computational Resources and other trainer equipment as appropriate."

The second possibility is a stand-alone TSS. In this configuration, separate computational hardware must be specified and provided for use independent of the Computational Subsystem hardware. Also, the TSS computational hardware must be exempted from the requirements of the Computational Subsystem hardware (see 3.7.2.2.1). This configuration would be used only in a multiple-unit acquisition where one trainer site (or a remote site) is designated to provide modification support for all other trainers. For this configuration, the blank should contain the following:

(The TSS shall be) "designed as a stand-alone subsystem of the trainer capable of independent operation."

In this case, two versions of the specification would be required: one for the trainer with the TSS, and another for the other trainers with the TSS section removed. Thus, it is important to consolidate modification support requirements only in this section of the specification. Non-modification-support requirements should not appear in this section.

Background and Sources: None available.

Lessons Learned: This section replaces the Development Engineering Prototype System (DEPS) found in past specifications. The major problem of the DEPS was that its function was never clearly established. It defined support requirements with no common basis. Requirements for the development (which belong ONLY in the SOW for a truly functional specification), mission support, modification support, maintenance and test of the trainer were gathered more or less haphazardly into the DEPS section. In this specification, those support functions necessary to be provided at each trainer site (in a multi-unit acquisition) are defined in each section of the spec as required. Support requirements which might be located at another site without affecting the current trainer configuration (i.e., modification support) are collected here in this section.

3.7.2.3.1 MODIFICATION SUPPORT HARDWARE.

"Hardware shall be provided to satisfy all modification support functional requirements specified herein. ______ ____________________________________."

Rationale and Guidance: This is an introductory paragraph for the TSS hardware requirements.

Performance Parameters: Two possibilities exist for filling in this blank.

- If the TSS is specified to be fully integrated into the trainer in 3.7.2.3, then the blank should be filled in with:

  "Utilization of other trainer hardware selected to fulfill other trainer requirements is allowable if such utilization will not interfere with the trainer's operation or mission support activities."

- If the TSS is specified as a stand-alone subsystem in 3.7.2.3 then fill in the blank as follows:

  "This hardware shall be capable of operation independent of all other trainer hardware. In addition, the hardware selected shall not be used to fulfill other than modification support functional requirements."

<u>Background and Sources</u>: None available.

<u>Lessons Learned</u>:

3.7.2.3.1.1 TSS COMPUTATIONAL HARDWARE.

"Modification support computational requirements shall be satisfied by ____.
All TSS computational hardware shall be subject to the general system requirements for Computational System hardware specified in 3.7.2.1.1 and 3.7.2.1.1.1."

<u>Rationale and Guidance</u>: This paragraph assures the inclusion of TSS computational hardware in the Computational System.

<u>Performance Parameters</u>: Two choices for this blank also exist.

- For an integrated TSS:
  "the hardware specified for the Computational Subsystem."

- For a stand-alone TSS:
  "the provision of computational hardware subject to the requirements of the following subparagraphs."

If the first choice is selected, the subparagraph of this section which follows (3.7.2.3.1.1.1) and sections 3.7.2.3.1.2 through 3.7.2.3.1.4 must be deleted.

<u>Background and Sources</u>: None available.

<u>Lessons Learned</u>:

3.7.2.3.1.1.1 TSS COMPUTER EQUIPMENT PERFORMANCE.

"The configuration of computer equipment selected for the TSS shall be capable of processing all modification support computer programs at speeds sufficient to satisfy all modification support functional requirements. All computer configurations shall include spare capacities in accordance with 3.7.2.1.1 and the requirements of this subsystem."

Rationale and Guidance: This paragraph establishes basic performance requirements for the computer equipment selected for the TSS.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: The requirements of this section are indeed extremely general. Performance requirements for a stand-alone modification support system do not need to be as stringent as performance requirements for real-time computational equipment utilized in actual system simulation. However, performance requirements for these support activities are not to be ignored. This paragraph ties the performance of the TSS computer equipment to the functional modification support requirements of the various subsystems. Specific performance constraints for a particular functional requirement will be reflected as a performance requirement of the TSS computer equipment.

3.7.2.3.1.2 TSS PERIPHERAL EQUIPMENT.

> "Peripheral equipment shall be provided as specified in the following subparagraphs. This equipment shall be sharable (program control switchable) among the TSS computer configurations as required. All peripheral equipment shall be taken into account for the verification of required spare capacities. The operational environment shall also be taken into account for the placement of the equipment in the facility where the TSS is located."

Rationale and Guidance: (See 3.7.2.2.1.4)

Performance Parameters: (See 3.7.2.2.1.4)

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.2.1 TSS MASS STORAGE EQUIPMENT.

> "Mass storage equipment shall be provided for the TSS which shall be compatible with the secondary mass storage of the Computational Subsystem. Additional mass storage equipment shall be provided as necessary to provide for the efficient implementation of all modification support activities required for the TSS."

Rationale and Guidance: Mass storage equipment is required to store CPS computer programs and data for CPS modification support activities and to provide for the efficient implementation of all modification support activities required for the TSS.

Performance Parameters: No input is required from the preparer. As with the Computational Subsystem requirement, the choice of equipment is left up to the contractor. Functional requirements may restrict the choice of equipment to a particular type but the philosophy of not restricting design for non-functional reasons will not have been violated.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.2.2 MODIFICATION SUPPORT CONSOLES.

"One or more support consoles shall be provided to facilitate user interface with all trainer modification support functions requiring the use of TSS computational hardware. The types, quantity, and placement of the consoles shall be a function of the need for concurrent modification support activity and all other modification support requirements."

Rationale and Guidance: (See 3.7.2.2.1.4.2.2)

Performance Parameters: (See 3.7.2.2.1.4.2.2)

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.2.3 TSS HARDCOPY EQUIPMENT.

"Equipment shall be provided to produce hardcopy output of all data which are displayable on any peripheral display equipment controlled by the TSS computational hardware. The selection of hardcopy equipment shall be based on hardcopy throughput requirements, reliability, maintainability, supportability, and life cycle cost."

Rationale and Guidance: Hardcopy equipment for modification support functions is necessary because of the inherent limitations in available information displayable at one time on peripheral display equipment.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.2.4 ADDITIONAL MODIFICATION SUPPORT PERIPHERAL EQUIPMENT.

> "In addition to the modification support peripheral equipment specified above, any additional modification support peripheral equipment necessary to support the modification of the trainer shall be provided. Included shall be all equipment necessary to support all digital storage technologies used in the trainer; i.e., read-only memory (ROM), programmable read-only memory (PROM), field programmable logic arrays (FPLAs), etc. The additional equipment shall be configured to operate directly or in conjunction with the TSS computational hardware as necessary and shall also be taken into account for the verification of required spare capacities."

Rationale and Guidance: This paragraph is intended to assure that any and all peripheral equipment necessary for the modification support of the trainer will be provided and included in spare capacity considerations.

Performance Parameters: Subsystem-unique modification support peripheral equipment should be identified in section 3.7.2.3.4 by the functional engineers responsible for the various subsystems.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.3 TSS SPARE CAPACITY AND GROWTH CAPABILITY.

> "The modification support hardware shall provide the spare capacities specified in the following subparagraphs. The capability shall be provided to verify the spare capacities specified. In addition, growth capability shall be provided as specified."

Rationale and Guidance: Spare and growth capacities are necessary for adaptation to changing modification support requirements (due to trainer enhancements) and for the efficient operation of the hardware.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: Projected changes to training or training support requirements usually have an effect upon modification support requirements.

3.7.2.3.1.3.1 MEMORY SPARE OR GROWTH.

"____________________ percent usable spare memory or memory expansion capability shall be provided to allow for changing modification support requirements over the life cycle of the trainer. This requirement shall apply separately to each type of memory in each computer configuration in the TSS computational hardware. The decision to provide spare, expansion, or a combination of both shall be based on life cycle cost."

Rationale and Guidance: (See 3.7.2.3.1.3)

Performance Parameters: Specify the minimum amount of spare or expansion memory to be provided or allowed for as a percentage of the total amount of memory provided. The recommended amount is 25 percent, although it should correlate closely with the Computational Subsystem spare requirement.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.3.2 MASS STORAGE SPARE AND GROWTH.

"a. Each unit of mass storage equipment which is used in a random access mode of operation shall have an on-line, spare storage capacity that is at least _________________ percent of its total capacity."

"b. The total on-line storage capacity of the mass storage equipment shall be increasable by ______________ percent (i.e., the addition of units shall be provided for)."

Rationale and Guidance: (See 3.7.2.3.1.3)

Performance Parameters: (Item a): Specify the minimum acceptable spare capacity. The recommended value is 50 percent of its allocated capacity.

(Item b): Specify the growth capability required. The recommended value is 100 percent (i.e., expansion from one unit to two).

Both of these parameters should correlate closely with the spare requirements of the Computational Subsystem for primary mass storage (3.7.2.2.1.5.5). The reason the spare requirement is restricted to random access mass storage equipment is that it would not make sense to specify spare for a serial access device such as a magnetic tape drive. All that the contractor would have to do to meet the requirement is supply a longer tape.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.3.3 I/O EXPANSION.

"The I/O capacity of the TSS computational hardware in terms of the addition of peripheral equipment (consoles, mass storage, etc.) shall be increasable by ____ percent."

Rationale and Guidance: (See 3.7.2.2.1.5.3)

Performance Parameters: The recommended value for this parameter is 50 percent. The contractor is free to provide spare or expansion capacity in whatever combination desired.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.1.4 TSS PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS.

"The TSS shall operate within the total trainer requirements, in accordance with the environmental characteristics of this specification. The TSS shall operate with the power available at the installation site. Means

shall be provided to eliminate transients, pulses, and other electrical noise that could cause TSS malfunctions."

Rationale and Guidance: The TSS should not create any special power supply requirements at the installation site but should be protected against damage from electrical hazards and power fluctuations.

Performance Parameters: This paragraph may not be needed if there is a system-level requirement which contains the same information.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.2 TSS MAINTENANCE AND TEST COMPUTER PROGRAMS.

"Computer programs/data shall be developed and provided to fully test the operation of the TSS and associated equipment in accordance with the requirements specified herein. These programs shall be designed to execute on the deliverable TSS computer configuration(s) and shall be controllable with a single modification support console. Hardcopy of the input and output parameters shall be an option at execution time."

Rationale and Guidance: The specified programs are required to assure maintainability and availability of the TSS for modification support activities.

Performance Parameters: No input is required from the preparer. Specific maintenance and test requirements are made in the following subparagraphs.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.2.1 TSS COMPUTER EQUIPMENT DIAGNOSTIC COMPUTER PROGRAMS.

"A complete set of diagnostic programs shall be provided to isolate equipment failures in the TSS. Except for the portions of test that check whether or not inputs can be received from and outputs can be transmitted to the equipment in question, all diagnostics shall be fully automatic. This means that once the user has loaded the diagnostics and set up initial conditions, the program

will automatically generate error indications (if any) on the console and hardcopy device. These programs shall be capable of automatic execution as a total package and as individual diagnostic checks. The diagnostics shall check each computer configuration and its options, and all memory units, peripheral units, and input/output units in the TSS."

Rationale and Guidance: Diagnostic programs to isolate hardware failures are necessary to maintain the TSS.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned: (See 3.7.2.2.2.4.1)

3.7.2.3.2.2 TSS EQUIPMENT TEST COMPUTER PROGRAMS.

"Computer programs/data shall be provided to check the proper functioning of all remaining TSS equipment and equipment controlled by TSS computational hardware."

Rationale and Guidance: This paragraph assures that some level of diagnostic capability shall be provided for all TSS equipment.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.2.3 SPARE CAPACITY VERIFICATION COMPUTER PROGRAMS.

"Computer programs/data shall be provided to verify the spare capacities specified for the modification support hardware. Optional hardcopy output shall be selectable when executing each program."

Rationale and Guidance: In order for spare capacity requirements to be meaningful, they must be verifiable. Hence, the requirement for these programs.

Performance Parameters: No modification of this paragraph is required.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.2.3.1 SPARE MEMORY AND MASS STORAGE VERIFICATION COMPUTER PROGRAMS.

"Computer programs shall be provided to verify the spare capacities specified for memory and mass storage. These programs shall provide the data from which calculations will be made to verify compliance. The spare memory data shall be obtained from the configuration of modification support activity which produces the maximum memory utilization. Computer vendor operating system built-in functions or utilities may be used if all requirements are satisfied."

Rationale and Guidance: (See 3.7.2.3.2.3)

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.3 MODIFICATION SUPPORT COMPUTER PROGRAMS/DATA.

"Computer programs/data shall be provided to support the modification of the Computational System and the interfaced major component subsystems which results from changes to the simulated equipment, air-vehicle, or crew stations (e.g., addition, deletion, or modification of equipment items, systems, or airborne digital multiplexed data busses, instrument changes, or other system modifications which force changes to be made to the trainer interface hardware). Computer vendor-supplied, commercial, off-the-shelf (unmodified) computer programs shall be provided wherever possible or required."

Rationale and Guidance: This paragraph establishes basic requirements for the provision of modification support computer programs/data which will be specified in the following subparagraphs.

Performance Parameters: No modification of this paragraph is required.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.3.1 TSS OPERATING SYSTEM.

"A standard computer vendor operating system (OS) shall be provided for each general-purpose digital computer in the TSS computational hardware. The OS must support multi-terminal interactive and batch processing modes of operation. The TSS OS may be the same as that provided for the Computational Subsystem if all modification support requirements are satisfied."

Rationale and Guidance: A standard computer vendor operating system has been proven to be necessary for the short- and long-term supportability of maintenance trainers. It assures hardware and software compatibility over the life cycle of the trainer if both vendor hardware and software are maintained at their latest revision levels.

Performance Parameters: No input is required from the preparer. It should be noted here that the SOW should require that all commercial software delivered with the trainer should be at the latest available revision level. The contractor may object to this requirement on the grounds that the revision level of software may change during the course of the contract. This is not a valid argument because the commercial software must be maintained at the latest revision levels throughout the life of the simulator. If a revision level changes during the software development phase, the contractor will be demonstrating that the software developed can readily adapt to changes in the commercial software (i.e., puts no "hooks" into the OS which are dependent upon a particular subroutine being at a particular memory location).

Background and Sources: None available.

Lessons Learned: (See 3.7.2.2.2).

3.7.2.3.3.2 COMPILERS/ASSEMBLERS.

"All compilers and assemblers used in the generation of the CPS shall be provided. The use of compilers and assemblers in the generation of the CPS shall be consistent with the programming language requirements of this specification. In addition any pre-compilers or source-code processors whose output is used as input to the compilers or assemblers shall be provided. Compilers and/or assemblers shall be provided for each type of computer used in the Computational System."

Rationale and Guidance: In accordance with the programming language and source code provision requirements, compilers and/or assemblers are required for the modification support of the trainer.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.3.3 LOADERS.

"All loaders, linking loaders, task builders, and any other computer programs used to establish the operational CPS configuration shall be provided. Standard computer vendor, off-the-shelf, commercial computer programs shall be used to satisfy this requirement to the maximum extent possible."

Rationale and Guidance: These computer programs are required to assure that the operational CPS configuration (i.e., the configuration of CPMs and CPCs within the "tasks" ready for execution on the computer equipment) will be easily modifiable.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.3.4 DATA BASE MANAGEMENT COMPUTER PROGRAMS.

"Computer programs/data shall be provided and used to develop and modify data bases which are directly related to Computational System hardware or other trainer hardware controlled by the Computational System (e.g., interface hardware address or configuration tables, mapping tables or data, etc.). This shall include the modification of data bases delivered to fulfill the functional requirements of the trainer subsystems (e.g., visual data base, radar landmass data base, etc.)."

Rationale and Guidance: This paragraph specifies the requirements for the types of support programs which are expected to be necessary for modifying the operational computer data bases delivered with the trainer.

Performance Parameters: No input is required from the preparer.

Background Sources: None available.

Lessons Learned:

3.7.2.3.3.5 TEXT EDITORS.

"Computer programs shall be provided to allow computer program source code to be easily altered or created. The programs shall utilize modification support consoles for user input and output. The programs shall allow the modification of all source code provided with the trainer (i.e., the modification of source code for each type of computer). Standard computer vendor, off-the-shelf, commercial computer programs shall be used to satisfy this requirement to the maximum extent possible."

Rationale and Guidance: This requirement assures that the individual CPMs provided with the trainer will be easily modifiable.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.3.6 DEVELOPMENT TOOLS.

"All computer program development tools used in the development of the CPS shall be provided. Examples of such computer programs are execution flow tracers, emulators, syntax analyzers, and debug computer programs. The programs shall utilize modification support consoles for user input and output."

Rationale and Guidance: If a computer program development tool was deemed useful enough to be used in the development of the CPS, it will also be useful in the modification support of the CPS.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.3.7 TSS MASS STORAGE COPY/COMPARATOR COMPUTER PROGRAMS.

"Computer programs shall be provided which shall satisfy the functional requirements specified for and be compatible with the Computational Subsystem mass storage copy/comparator computer programs (3.7.2.2.2.3.1) for all types of mass storage used in the TSS. The programs shall utilize a modification support console for user input and output. Hardcopy of all console output shall be selectable by the user."

Rationale and Guidance: This capability is required to put CPS updates on media suitable for delivery to and installation on the trainer Computational Subsystem.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.4 MODIFICATION SUPPORT DOCUMENTATION.

"Documentation shall be provided for the modification support of the trainer. This documentation shall contain both the system level (preliminary) and detailed design for all modifiable portions of the trainer. This documentation shall be provided for both hardware and computer programs/data as necessary. Commercial-format documentation may be provided for commercial off-the-shelf (unmodified) hardware and computer programs if the functioning of the commercial product is not integral to the design of the real-time system simulation."

Rationale and Guidance: Documentation of the trainer design is required for the modification support of the trainer. The scope of the required documentation is defined in this paragraph.

Performance Parameters: No input is required from the preparer. However, this paragraph must be consistent with the requirements of the SOW and CDRL. In certain cases, commercial-format documentation may be disallowed or, in fact, allowed for all commercial products in the trainer.

Background and Sources: See AFHRL-TP-84-49, paragraph 2.5.2.6, for a discussion of logistical considerations affecting the need for modification support documentation.

Lessons Learned:

3.7.2.3.4.1 HARDWARE MODIFICATION SUPPORT DOCUMENTATION.

"The modification support documentation for trainer hardware shall include a product specification which describes the delivered trainer configuration, detailed subsystem product specifications as necessary, and any other documentation such as schematic diagrams, drawings, interface diagrams, etc., which would be necessary or helpful in the modification of any trainer hardware."

Rationale and Guidance: This paragraph establishes the scope of the required documentation for the modification support of trainer hardware.

Performance Parameters: No input is required from the preparer. However, additional documentation requirements may be added as appropriate.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.4.2 CPS MODIFICATION SUPPORT DOCUMENTATION.

"Documentation shall be provided for all elements of the CPS to support its modification. Included in the documentation shall be (1) a computer program development plan which establishes and documents the planning, procedures, and design standards used during the development of the CPS and which should continue to be used throughout the trainer's life cycle for its modification support (to ensure consistency), (2) a computer program development specification which defines the system-level design of the CPS and defines all hardware interfaces, (3) one or more computer program product specifications which describe the detailed design of all computer programs used in the real-time simulation of any systems and those computer programs used to interface with the trainer hardware or commercial computer programs. For those commercial computer programs not subject to item (3) above, commercial-format documentation shall be provided. Source code shall be provided for all computer programs except those commercial computer programs for which source code is not economically available. For those computer programs for which source code is not delivered, a waiver must be requested identifying the problem and the reasons for the waiver. However, the functional design of these programs shall be documented to a level sufficient to allow a replacement to be

developed, supplementing the commercial documentation as necessary."

Rationale and Guidance: This paragraph establishes the content requirements for CPS modification support documentation.

Performance Parameters: No input is required from the preparer. The SOW and CDRL requirements must reinforce the requirements stated here.

Background and Sources: None available.

Lessons Learned: In the past, source code has been required for all computer programs in the trainer. In very few cases has all the source code been delivered. Proprietary data laws have forced the Air Force to accept computer programs without source code. This specification recognizes that source code may not be available for every computer program in the trainer, but it must be available for those critical functions which are most likely to undergo modification during the trainer's lifetime, for proprietary programs modified for use on this trainer, and for programs produced for this trainer.

3.7.2.3.5 SUBSYSTEM-UNIQUE MODIFICATION SUPPORT REQUIREMENTS.

"The TSS shall provide hardware and computer programs as necessary to meet the requirements defined in the following subparagraphs for the modification support of the trainer subsystems."

Rationale and Guidance: This paragraph is just an introductory paragraph for those paragraphs in which subsystem-unique modification support requirements are defined.

Performance Parameters: No modification of this paragraph is necessary.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.5.1 COMPUTATIONAL SUBSYSTEM MODIFICATION SUPPORT.

"The following modification support requirements shall be met for the Computational Subsystem."

Rationale and Guidance: (See 3.7.2.3.5).

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.2.3.5.1.1 CPS GENERATION COMPUTER PROGRAMS.

"Computer programs/data shall be provided to perform a complete software object-code generation ("cold-start") of the operational CPS. This shall include the automatic compilation/assembly of all available source code into CPEs, the generation of all CDFs, and the combination of the CPEs and CDFs into CPMs and CPCs and tasks ready for execution on the Computational Subsystem. The programs shall be designed to require a minimum of user input and shall allow for the optional generation of hardcopy of all console output and all listing files generated by the compilers, assemblers, or loaders utilized in the process."

Rationale and Guidance: Cold-start is used to establish a baseline CPS configuration and since it can be such a long and tedious process, its automation is desirable. When the CPS undergoes extensive change, a cold-start should be performed.

Performance Parameters: No input is required from the preparer.

Background and Sources: None available.

Lessons Learned:

3.7.3 OTHER MAJOR COMPONENTS.

"____
____."

Rationale and Guidance: This subparagraph contains space to describe the other major components. Notice that subparagraph 3.7.1 describes the instructional systems programs, while subparagraph 3.7.2 describes the computational system. These are only two of the major components of any trainer.

Other possible major components are the Instructor Station and the Student Station. The preparer should check subparagraph 3.1.3 of the Prime Item Development Specification before preparing this subparagraph. Subparagraph 3.1.3 should list all the required

major components. Those components not discussed in subparagraphs 3.7.1 and 3.7.2 should be discussed in this subparagraph. For convenience, the preparer may wish to give each of the remaining major components its own subparagraph heading and identification number; e.g., 3.7.3, INSTRUCTOR STATION; 3.7.4, STUDENT STATION, etc.

Performance Parameters: Since it is impossible, in a generic specification, to address all major components that might be on a maintenance trainer, only certain major components are discussed here. It is not the intent of this Handbook to force a configuration on the maintenance trainer. However, most trainers have a student station and an instructor station. Each of these is discussed below.

Instructor Station. In discussing the instructor station, the preparer should consider the following:

"The following subcomponents shall be located on the instructor station:

a. The computational system hardware specified in subparagraph 3.7.2 herein (e.g., the computer or processor, the keyboard, the CRT or display system) with the exception of the following: ______________ ____.

All computational system hardware specified herein shall meet the requirements established in subparagraph 3.7.2."

The preparer should enter the exceptions in the space provided; e.g., it may not be desirable to have the storage device or printer located on the instructor station. If location on the instructor station is not desired, the exceptions should be entered in the space provided.

Continuing the list:

"b. Instructional features controls:

(1) On-off/select sensing.

(2) On-off/select recording.

(3) On-off/select scoring.

(4) On-off/select reporting.

(5) On-off/select monitoring.

(6) On-off/select feedback message control.

(7) On-off/select feedback message adjust.

(8) Rate adjust control.

(9) Signal-to-noise adjust control.

(10) Cue enhancement control.

(11) On-off/select next activity.

(12) On-off/select freeze control activity.

Each of the instructional features controls is further defined in Appendix A of this document. It should be noted that if these instructional features are being controlled by the software, then none of these controls will be needed on the instructor station since these controls would be built into the software and communicated via the keyboard.

Continuing the list of components on the instructor station:

"c. Repeater or slave display and controls. The following displays and controls shall be located on the instructor station. These controls and displays are duplicates of displays and controls located on the *student station so that the instructor can monitor* the student's performance:

(1) ______________________________
____

.
.
.

(n) ______________________________
______________________________."

The preparer should insert the list of repeater or slave displays and controls. It should be noted that if the software is going to monitor the student's performance, then the above item may be deleted.

Continuing the list of components on the instructor station:

"d. Projection system. The projection system shall meet the following requirements:

access, 35mm slide
provided. The projector
and a maximum slide search
system shall have two
manual. In the automatic
led by the computer to
determined by the training
means shall be provided to
slides stored in the
on or off. The
of storing and
of 80 - 35mm (or any 2-
The projector storage
commercially
In addition, the
change of individual
entire storage
the projection system
the projection screen and
The projector and
installed in the trainer
accessible to the
and slide storage shall
of tools for slide
The viewing screen
projected type with a minimum
trainer shall contain
the addition of a second

instructor station. If so,
above.

station, the preparer

located on the

described in

specified

The preparer should insert the computational system hardware that is to be located on the student station. This might include any of the following: CRT or display system, alphanumeric keyboard, cassette tape device, etc.

To continue the list of subcomponents on the student station:

"c. The following instructional features controls:

(1) ______________________________.

(2) ______________________________."

The preparer should insert any of the controls for the instructional features that might be located on the student station. Essentially any of the instructional features controls (listed in Appendix A) can be located on the student station. The decision to place instructional features controls on the student station depends upon the desire to have the student control certain aspects of the learning environment. For example, it may be advantageous for the student to control the level of cueing. It should be noted that if these features are to be software controlled, then there should be no need to have specific controls on the student station.

To continue the list of subcomponents on the student station:

"d. Projection system screen. The projection system screen shall have the following characteristics:

(1) ______________________________.

(2) ______________________________."

The preparer should insert specific characteristics for the screen; e.g.,

"The screen shall have, at a minimum, the following dimensions: _____ (meters) by _____ (meters)."

"The screen shall be of material which is durable enough to withstand student use."

The preparer should list any other subcomponents which are to be part of the student station.

Other Components. In addition to the instructor station and the student station, the trainer may have other components; e.g., dust covers or casters and jacks.

For dus [illegible] be entered:

"Cove [illegible] accordance with subparagraph 3.3.3. [illegible]"

For caste [illegible] wing wording from MIL-T-81821, paragrap [illegible]

"Each [illegible] casters shall be equ [illegible] four (4) ball-bearing, full-swi [illegible] casters which meet the requi [illegible] least two (2) of the cas [illegible] the trainer panel support frame [illegible] casters shall be fa [illegible] alloy and shall be e [illegible] tread aluminum alloy whee [illegible] inches in width. Extruded al [illegible] plates, countersunk into the [illegible] shall be provided on all [illegible] provisions shall be made for remov [illegible] metal support frame for shippi [illegible] base plate shall be [illegible] wide, four (4) inches long, and [illegible] shall be fitted with a [illegible] the casters in a caster [illegible] base or frame. The casters [illegible] the trainer panel while in [illegible]. Each caster shall not [illegible] point floor loading greater th [illegible]"

Also co [illegible] wing wording from MIL-T-81821, paragr [illegible]

"Wh [illegible] the trainer panel requires [illegible] screw type jacks, one each [illegible] each caster on the trainer ba [illegible] retracting, leveling, rem [illegible]. The jacks shall be ca [illegible] while in use for extended [illegible] impose a concentrated [illegible] than 100 [illegible]

<u>Backgr</u> [illegible] provided in the discussion given [illegible]

<u>Lesso</u> [illegible]

3.8 PRECEDENCE.

"a. The precedence of the requirements specified herein shall be as follows: ______________________________ ______________________________."

"b. The precedence of referenced documents shall be in accordance with subparagraph 2.1 of this specification."

Rationale and Guidance: MIL-STD-490, subparagraph 20.3.8, page 36, provides the following guidance:

> "This paragraph shall either specify the order of precedence of requirements or assign weights to indicate the relative importance of characteristics and other requirements. These include requirements allocated from item requirements as well as requirements which are peculiar to the major components and cannot be directly referenced to item requirements. It shall also establish the order of precedence of this specification relative to referenced documents."

From the information provided in MIL-STD-490, it is clear that two types of precedence need to be established;

1. Precedence of the requirements specified in the Prime *Item Development Specification.*

2. Precedence of the referenced documents.

For a discussion of how each type of precedence is specified, see the Performance Parameters section of this subparagraph.

Performance Parameters: This subparagraph contains two items. Item b establishes the precedence of the referenced documents. Since precedence is established in subparagraph 2.1, all that needs to be specified here is that precedence is in accordance with subparagraph 2.1.

Item a requires the preparer to specify the precedence of the requirements set forth within the specification (including the requirements established for the major components). This can be accomplished by listing the subparagraph numbers in the order of their importance or by assigning weights to the subparagraphs. It is very difficult to determine the order of importance. All the requirements specified in the Prime Item Development Specification are important (or else they would not be included in the specification). Although all the requirements are important, it

should not be forgotten that the trainer's mission is to train the students; i.e., it is important that the trainer can be used by the instructors to guarantee that the learning objectives are achieved by the students. It should also not be forgotten that it is very important that the trainer be flexible; i.e., the trainer should allow the instructor freedom in using the trainer as a training tool. The trainer should be easily updated to keep it current with the system or subsystem being simulated.

It would be inappropriate for this Handbook to suggest precedence of requirements, since this may vary from application to application.

Background and Sources: See Rationale and Guidance section of this subparagraph.

Lessons Learned: A review of recent specifications indicates that not many rank the requirements according to importance. However, all the specifications included a statement concerning the precedence of documents.

4.0 QUALITY ASSURANCE PROGRAM.

4.1 QUALITY ASSURANCE PROGRAM, GENERAL.

"____
____."

Rationale and Guidance: This subparagraph allows the preparer to specify any general requirements concerning the Quality Assurance Program. Before discussing the Performance Parameters to be entered, it may be helpful to discuss briefly the quality assurance program for maintenance of trainers.

The quality assurance program for maintenance trainers is somewhat different than the quality assurance program for other types of equipment (e.g., an aircraft). When an aircraft is purchased, a prototype or pre-production model is required. This is not, typically, true for maintenance trainers. The first production model and the prototype are one and the same.

Although not required, the preparer may find it convenient in this subparagraph to specify the type of quality assurance tests that will make up or compose the quality assurance program. To assist the preparer, the following brief description is offered.

In the past, quality assurance tests have been divided into two categories. Category I tests are performed to verify all the requirements established in Section 3.0 of the specification, with the exception of availability, maintainability, and operating environmental tests. Usually availability, maintainability, and operating environmental tests are verified as part of the Category II testing activity.

Category I tests include:

- Engineering Test and Evaluation (ET&E). These are tests designed to support the design and development of the maintenance trainer. These are particularly useful tests when a prototype is being developed. These types of tests are usually not performed on a maintenance trainer unless the preparer has some strong reasons to require them.

- Preliminary Qualification Tests. These are tests primary conducted by the contractor or vendor (and monitored by the Government). These tests are designed to verify the requirements established in section three of the specification. Typically, these tests are performed by the contractor or vendor before the formal qualification tests to assure the contractor or vendor that the requirements in the specification have been met.

- Formal Qualification Tests. These tests are performed by the Air Force (with facility, test equipment, and personnel support from the contractor or vendor). These tests are also designed to verify the requirements specified in the procurement specification. This verification is performed by one or more of the following techniques: inspection, analysis, demonstration, and formal test procedures.

Category II tests include:

- Formal reliability verification.
- Formal maintainability verification.
- Formal availability verification.

The concept of Category I and II tests has somewhat faded for maintenance trainers in the past 5 to 10 years. Typically, verification tests are not classified by Category I or II tests. The procedure or sequence that has been used in the past for maintenance trainers is as follows:

- Preliminary Qualification Tests. The contractor or vendor is, typically, given the responsibility to conduct these tests. The conduct of the tests and the results of the test, however, are monitored by the Air Force (by a Cognizant Government Plant Representative).

- Formal Qualification Tests. These tests are primarily conducted by the Air Force, with support from the contractor or vendor. These are usually conducted at the contractor's or vendor's facility (using contractor or vendor test equipment and personnel for support). The formal qualification tests can be divided into several parts. First, the engineering requirements specified in the specification are verified. Following this verification, the maintenance trainer is verified for its ability to perform the training mission; i.e., every learning exercise should be verified in the operational mode (see paragraphs 3.2 through 3.2.1.5.9 of the Prime Item Development Specification). Instructors should be required to try every exercise to assure that the training objectives can be achieved. This operational test should be performed in the free-play mode, and the T.O.s (or tasks to be trained) should be verified. (Do activities and indications occur the way they should? Does the trainer respond the way it should?)

- Acceptance Test Procedure (ATP). Following the formal acceptance test, an acceptance test procedure should be developed and verified. The ATP is the procedure which is used to test additional production units. Notice that

not all the requirements should be verified for every additional unit. For example, once spare capability is verified, it need not be verified on additional units. The ATP should verify only those things that can vary from unit to unit. The ATP is developed by the contractor or vendor, with active participation by the Air Force. The acceptance test procedure itself is verified on the first unit produced at the contractor's or vendor's facility.

- Reliability/Maintainability/Availability Tests. Either during the ATP or following it, reliability, maintainability, and availability tests can be conducted. If these are formal tests, they can take a long time. Typically, the trainer is operated for some period of time, and the reliability and maintainability are documented. There is some question whether sophisticated reliability and maintainability tests are required on the maintenance trainers. Often, maintenance trainers are composed of off-the-shelf equipment which has been tested for reliability by the supplier. Sophisticated reliability and maintainability tests may not be worth the money.

- Functional Configuration Audit (FCA) and Physical Configuration Audit (PCA). These are tests performed on any additional units purchased. However, the FCA and PCA are usually conducted on the first unit after the ATP. These tests are primarily conducted to document possible deficiencies.

The preparer should also consider specifying the type of tests, if any, that are to be performed after the delivery of the unit to the using site. Typically, maintenance trainers (because they are mobile) are "bought-off" in the contractor's or vendor's plant. They are prepared for shipping by the contractor or vendor. Delivery is usually assumed by the Air Force. After delivery, the trainer is installed (usually by the Air Force with the assistance of the contractor or vendor). After installation, it makes sense to suggest that the trainer again be tested (to assure that it operates, or to assure that deficiencies were corrected). Thus, the preparer might consider specifying these tests as part of the quality assurance program.

<u>Performance Parameters</u>: This subparagraph provides the preparer an opportunity to specify any general requirements on the quality assurance program. MIL-T-23991E, paragraph 4.1 (pages 55 and 56) states the following general requirement:

"An organized quality assurance program shall be established by the contractor in accordance with MIL-Q-9858. The program shall ensure quality throughout all areas of the specification requirements including: design, development, fabrication, processing, assembly, inspection, test, maintenance, preparation for delivery, shipping, storage, and site installation. Certain requirements herein, such as testing, may be considered common to the Quality, Reliability, and Maintainability Programs. The contractor's quality assurance program shall be planned and utilized in a manner to effectively support the contractor's Reliability and Maintainability Programs."

The same intent is also indicated in MIL-T-81821, paragraphs 4.1 and 4.1.1.

Some specifications reviewed also contain a statement concerning the intent of this section of the specification; e.g., the following wording is added:

"This section of the specification establishes the verification of the requirements established in section three of this specification. A verification cross-reference index (VCRI) is provided in subparagraph 4.2, herein. The VCRI provides for the accountability of each requirement in section 3.0."

Although this general requirement may be useful to place in the specification, it is also recommended that the preparer insert the tests that will be conducted, as well as a brief description of these tests. To do this, the preparer must first determine which tests are to be conducted. Below is a list of possible tests, as well as brief descriptions. These brief descriptions can be entered into the specification. It should be noted that the list does not contain specific or special tests. Special tests and specific tests are described in subparagraph 4.1.2. It should also be noted that the list offered is not meant to be exhaustive or complete.

The following wording is suggested:

"The tests to be performed on the maintenance trainer are as follows:

- Engineering Test and Evaluation (ET&E). These tests shall be made to support the design and development of the maintenance trainer. Engineering Test and Evaluation shall include computer program test and evaluation.

- Preliminary Qualification Tests. These tests shall be conducted to verify that the maintenance trainer meets the requirements specified in the specification. Preliminary qualification tests shall also be performed on the computer programs. For computer programs, these tests shall be oriented primarily towards verifying portions of the programs prior to the integrated testing that takes place during the formal qualification tests.

- Formal Qualification Tests. These formal tests shall be conducted to verify that the maintenance trainer meets the requirements specified in the specification. The formal qualification tests shall include formal tests of the computer programs. The computer program's formal tests shall be oriented primarily towards the integration of the computer programs using operationally configured equipment. These formal qualification tests shall include an opportunity for the instructor (Air Force personnel) to operate the trainer to determine if the training missions can be accomplished. This operational test shall emphasize the ability of the trainer to perform according to the specified training objectives. In addition, this test shall be made to assure that the requirements established by ISD analysis have been met (see paragraphs 3.2 through 3.2.1.5.9 of the Prime Item Development Specification).

- Acceptance Test Procedures (ATP). Tests shall be conducted to verify the developed acceptance test procedure. The ATP shall be verified using the first unit. Many of the tests in the ATP shall be the same as those in the formal qualification tests.

- Reliability tests shall be conducted in accordance with the requirements specified in subparagraph 4.2, herein.

- Maintainability tests shall be conducted in accordance with the requirements specified in subparagraph 4.2, herein.

- Availability tests shall be conducted in accordance with the requirements specified in subparagraph 4.2, herein.

- Functional Configuration Audit (FCA) shall be performed to assure that test/analysis data for a given

unit verifies that the item has achieved the performance specified in its functional or allocated configuration identification, and to assure that the contractor or vendor maintains internal technical documentation that describes the physical configuration of each unit of the item for which test/analysis data were verified. The Functional Configuration Audit shall also be conducted on the software and the Computational System.

- Physical Configuration Audit (PCA) shall be performed after the FCA to assure that the as-built configuration of the unit matches the same unit's production configuration identification or that differences are reconciled. The Physical Configuration Audit shall also be conducted on the Computational System.

- After installation, testing shall be performed to assure that the delivered unit operates as specified."

Notice that each test is described briefly and the preparer is encouraged to add any additional useful information.

Background and Sources: The preparer is encouraged to see MIL-STD-483 for tests dealing with computer programs. Also see AFHRL-TP-84-49, paragraphs 2.3.2.1 and 2.3.2.3, for information on logistics factors associated with start-up and formative evaluation.

Lessons Learned: Several issues need to be addressed concerning the specification of the tests that comprise the quality assurance program.

First, the preparer should specify in the contract all the necessary Data Item Descriptions (DIDs) which support the Quality Assurance Program. The preparer is encouraged to read subparagraph 3.4 of this Handbook for possible guidance. Without the supporting DIDs, the Quality Assurance Program may not be effective.

Second, the test which should receive the most attention in this subparagraph is the Formal Quality Assurance Test. It is imperative that this test be divided into two components. One component should concern the engineering requirements specified in section 3.0. The other component should stress the operational test (i.e., the test concerning the trainer's ability to achieve the specified training mission). It should be stressed that the instructors should be involved in the operational test. The trainer should be tested to verify that the results obtained during the ISD analysis are incorporated into the trainer. In

fact, it is suggested that the ISD-Based Training Equipment Design Specification be used extensively during this part of the Formal Quality Assurance Test. The instructor or Air Force representative should operate the trainer as it would be operated in the training situation. Each task and malfunction presented by the trainer should be verified. The instructor or Air Force representative should try to perform each task and each malfunction isolation. The responses of the trainer should be checked against the appropriate T.O.s. It is also important to check how the instructional features work (if the trainer has any). Of particular concern is the ability of the instructor to create new training exercises (if this is a requirement for the trainer). It is during the operational testing component of the Formal Qualification Test that most of the "problems" are discovered.

Third, it is also important during the formal qualification, as well as tests, to check or verify the computer programs. This is why each of the descriptions above discuss a computer program component. Verification of computer programs are also discussed in subparagraph 4.2 of this Handbook.

4.1.1 RESPONSIBILITY FOR TESTS.

"a. All tests shall be conducted by: ________________
____."

"b. The conditions of testing shall be as follows:
____."

This subparagraph contains two items to be completed by the preparer. Each item is discussed separately below.

Rationale and Guidance (Item a): It is necessary to specify who has responsibility for conducting the quality assurance tests. Typically, the contractor or vendor is given this responsibility, but the Air Force assumes a role of active participation. In actual practice the Air Force takes the lead during the formal qualification tests and is supported by the contractor or vendor. (Typically, the contractor or vendor supplies test equipment facilities and personnel.)

It is possible to say directly, in the specification, that the Air Force will assume responsibility; however, to do so locks the Air Force into performing the tests. For this reason, this requirement is usually written so as to specify that the contractor or vendor is primarily responsible and the Air Force will actively participate to the level they deem necessary. This approach then allows the Air Force to assume the primary lead. By specifying that the contractor or vendor has the primary

responsibility, it also allows the contractor or vendor to adequately supply a bid. If the requirement was written specifying that the Air Force had primary responsibility, but the contractor or vendor was to supply support personnel and test equipment, it would be difficult for the contractor or vendor to construct a bid (since the level of actual support might not be precisely known).

Performance Parameters (Item a): Item a requests the specification of the person or group responsible for conducting the quality assurance tests (either the Air Force or the contractor or vendor). It should be noted that many tests were specified in subparagraph 4.1. The responsibility specified within this item refers to the tests specified in subparagraph 4.1. If the preparer decides that all the tests specified in subparagraph 4.1 should be the responsibility of one group, then a blanket statement can be inserted; e.g.,

> "All tests shall be conducted by the contractor or vendor with active participation of the Air Force. The procuring activity shall reserve the right to perform any of the tests specified herein, where such tests are deemed necessary to assure conformance to the prescribed requirements."

If the preparer decides that different groups should have different responsibilities, then each test listed should be discussed in terms of who has what responsibility; i.e., each test specified in subparagraph 4.1 should be listed within this subparagraph with the specification of who has responsibility for conducting the test.

Background and Sources (Item a): This requirement is specified by MIL-STD-490, paragraph 10.4.1.1 (page 32).

Lessons Learned (Item a): Although the Air Force may take primary responsibility, it appears more practical to specify that the Air Force will actively participate in the tests, with the contractor or vendor specifying the needed support.

> "b. The conditions of testing shall be as follows:
> ____
> ____."

Rationale and Guidance (Item b): Item b requests the preparer to specify the conditions of the tests. Typically, the conditions specified refer to:

- The location of the tests.
- The test equipment used.

Often the environmental characteristics of the tests are also specified. However, this is usually not critical when dealing with maintenance trainers. Environmental specifications would be required only if the trainer is to be used in an extreme environment.

Performance Parameters (Item b): The following paragraph has been prepared for consideration, from MIL-T-81821:

> "Except as otherwise specified in the contract or order, the contractor shall use his or her own facility or any other facility suitable for the performance or verification tests, unless disapproved by the Government. The contractor shall provide engineering-level and technician level personnel and all test equipment as necessary to support and conduct the tests. All test equipment shall be checked and calibrated prior to the start of any test. Calibration charts and conversion tables shall be available during the tests. The Government reserves the right to perform any of the verification tests set forth in this specification where such verification tests are deemed necessary to assure supplies and service conform to the prescribed requirements."

Background and Sources (Item b): See MIL-T-81821, subparagraph 4.1.1 for additional guidance.

Lessons Learned (Item b): As stated above, some specifications have provided a description of the environment in which the tests will take place. If deemed necessary, the preparer should specify:

- Ambient temperature.
- Altitude.
- Humidity.
- Vibration.
- Noise levels.
- Illumination levels.

The quantities provided should reflect the normal operating ranges for the trainer. Typically, the environment in which the tests are conducted is not specified for a maintenance trainer.

4.1.1.1 TEST SCHEDULE.

"The test schedule shall be as follows: ______________ ____."

Rationale and Guidance: MIL-STD-490 does not require the insertion of the test schedule. However, the test schedule may provide the contractor or vendor with some guidance in preparing the quality assurance program documentation (usually required by DIDs).

Performance Parameters: Each test specified in subparagraph 4.1 should be assigned a position on the schedule. The schedule may not actually specify a date, but should specify an event date and/or display the sequence of the various tests.

The preparer should enter any proposed test schedule deemed necessary. It may be sufficient to list the events or tests that are to occur, in their sequential order.

Background and Sources: No source exists for this requirement.

Lessons Learned:

4.1.2 SPECIAL TESTS/SPECIFIC TESTS.

"Special test and specific test requirements shall be as follows:

a. Operational Tests. The operational test shall be performed to assess the trainer's ability to satisfactorily complete its training mission, as defined herein and by the ISD (Instructional System Development) analysis (see ISD-Based Training Equipment Design Specification for the results of the ISD analysis). During the operational test, the training exercises shall be conducted just as they would be in the training environment. The responses of the trainer shall be verified against the available T.O.s, the results of the ISD analysis, and the base line data provided at CDR (critical design review). The Air Force shall be given the opportunity to test the trainer in the free-play mode. If the training exercises permit different student paths through the completion of a given exercise, representative paths shall be verified. During the operational test, unlikely responses (responses which untrained students might make) shall be tried and their conse- quences recorded. If the trainer is designed to allow instructors the opportunity to create new training exercises, part of the operational test shall consist of creating at least one new exercise.

Other operational test requirements shall be as follows: ________________________________
____.

b. Reliability Tests. The reliability test requirements shall be as follows: ____________________
____.

c. Maintainability Tests. The maintainability test requirements shall be as follows: ______________
____.

d. Software (computer program) Diagnostic Tests. The software test requirements shall be as follows: ___
____.

e. Human Factors Compliance Tests. The human factors compliance test requirements shall be as follows:
____
____.

f. Other tests: ________________________________
____."

Rationale and Guidance: The verification cross-reference index offered in subparagraph 4.2 provides only general guidance concerning the methods of requirement verification. Where the methods of verification are tests (as specified in subparagraph 4.2), then the preparer may find it necessary to describe these tests further. This subparagraph provides an opportunity for this further specification. Sometimes it may even be necessary to describe methods of verification other than tests. If this is the case, then this subparagraph can be used for these purposes.

MIL-T-81821 describes the following special and specific tests:

- Human factors compliance tests.
- Operating tests.
- Electromagnetic Interference Suppression tests.
- Reliability tests.
- Maintainability tests.
- Maintainability verification.
- Other tests.
  - Temperature measuring.
  - Controls and circuits.
  - Functional tests.
  - Structural tests.
  - Power tests.
  - Environmental tests.

Another surveyed document provided the following list of special and specific tests:

- Functional.
- Trainer operation.
- Structural.
- Electrical.
- Grounding and grounding system.
- Human factors engineering compliance.
- Reliability.
- Environmental.
- Electromagnetic interference suppression.

The lists from both documents are comparable. However, the reader should be warned that the two documents use different names for the same tests. Absent from the list are those tests appropriate for verification of the software/computer programs.

Some of the special tests are listed in the Prime Item Development Specification itself; e.g., operational tests, reliability tests, maintainability tests, software tests, and human factors compliance tests. However, provisions are made to specify other special tests. Each of the special tests is discussed in the Performance Parameters section of this subparagraph.

For convenience, the preparer may find it useful to give each special or specific test its own subparagraph number (e.g., 4.1.2.1 OPERATIONAL TESTS, 4.1.2.2 RELIABILITY TESTS, 4.1.2.3 MAINTAINABILITY TESTS, etc.).

Performance Parameters: The tests of most interest probably are operational, reliability, maintainability, and software tests. Thus, it seems reasonable to discuss these first.

Operational Tests. The Prime Item Development Specification, item a of this subparagraph 4.1.2, already states some requirements:

"a. Operational Tests. The operational test shall be performed to assess the trainer's ability to satisfactorily complete its training mission as defined herein and by the ISD (Instructional System Development) analysis (see ISD-Based Training Equipment Design Specification for the results of the ISD analysis). During the operational test, the training exercises shall be conducted just as they would be in the training environment. The responses of the trainer shall be verified against the available T.O.s, the results of the ISD analysis, and the baseline data provided at CDR (critical design review). The Air Force shall be given the

opportunity to test the trainer in the free-play mode. If the training exercises permit different student paths through the completion of a given exercise, representative paths shall be verified. During the operational test, unlikely responses (responses which untrained students might make) shall be tried and their consequences recorded. If the trainer is designed to allow instructors the opportunity to create new training exercises, part of the operational test shall consist of creating at least one new exercise."

These requirements were designed to inform the contractor or vendor that the operational test of the trainer is important. It must be determined if the trainer can satisfy its training mission as defined by the ISD analysis. That is, if the trainer is not capable of satisfying its training mission, then the trainer will be of little use to the instructors. In order to conduct the operational tests(s), it is recommended that the document produced by the ISD analyst be used; i.e., the ISD-Based Training Equipment Design Specification be used as a guide during the operational test. Each of the training objectives specified in the ISD-Based Training Equipment Design Specification should be evaluated to determine if it can be taught or acquired using the trainer. Each of the training exercises should be tried in a free-play mode or format. The exercises should be tried just as they would be used in the training environment. If the exercise permits students to go through different paths, each of these paths should be verified against the ISD results, the T.O.s, and the data supplied during the CDR. Furthermore, if the trainer has provisions for creating "new" exercises, at least one exercise should be created during the operational test.

It is encouraged that the ISD analysts and/or the instructor be present during the operational test. In fact, the instructor and/or ISD analyst should be the primary personnel conducting the operational test (perhaps with the assistance of the contractor or vendor).

There are other requirements which might be specified concerning the operational test. MIL-T-81821, paragraph 4.2.4.2 specifies the following:

"The trainer panel or system shall be energized for a period of one (1) hour and subjected to an operating test in an ambient temperature for sixty-eight (68) degrees F $\pm$ five (5) degrees F of not less than six (6) hours to insure the proper functioning of the panel, including all operating controls, supply line voltage, ranges and frequencies, conditions of extreme limits,

> and conformance to applicable safety requirements. During the operation period not less than three (3) complete cycles of operation shall be accomplished in the presence of the Government inspector to demonstrate compliance with the requirements of the applicable specification. A cycle of operation is considered to be one complete end to end sequential operation of the trainer in accordance with the operating instruction contained in the trainer MOMI, regardless of the time required. The trainer panel shall be capable of meeting the performance requirements without alignment or adjustment other than the accessible controls employed for operation of the panel. No repairs shall be permitted during the operational tests. If repairs are required, the test shall be repeated after the necessary repairs or replacements have been made. Trainers requiring interconnection for complete system demonstration shall be tested as a unit to ensure proper operation of all components. Associated trainer power supply equipment, such as power conversion units, direct-current power units, cables and power distribution junction boxes, and also all applicable system Ground Support Equipment (GSE) and special tools shall be functionally tested in conjunction with applicable trainers prior to delivery."

Also consider the following wording:

> "The training device shall be tested to determine the suitability of controls and control circuits for satisfactory mechanical and electrical operation."

The requirements specified in MIL-T-81821 are interesting and useful, but they fail to convey to the contractor or vendor the importance of verifying if the trainer can, in fact, satisfy its intended training mission. Thus, a conscious effort must be made to inform the contractor or vendor that the primary purpose of the operational test is to verify the student exercises and assess the ability of the trainer to meet the specified learning objectives. It is for this reason that item a of subparagraph 4.1.2 was constructed and placed in the Prime Item Development Specification.

Reliability Tests. It should be noted that most trainers are composed of commercially available equipment. Typically, commercially available equipment has already gone through extensive reliability testing by the manufacturer. It has been questioned,

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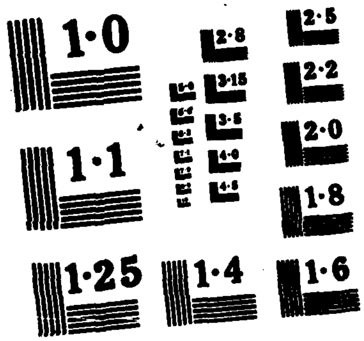
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therefore, whether the Air Force should require extensive and sophisticated reliability and maintainability testing of the trainer. The costs incurred may not be worth the benefits received. It has also been questioned whether or not the Air Force, in requiring extensive and sophisticated reliability testing, is paying for something that has already been done by the manufacturer. Proponents of this philosophy recommend that it is better to run the trainer in the training environment and note the downtime, rather than spending the money for sophisticated tests which can take 2 to 3 months. If this approach is taken, then reliability may be verified through analysis or demonstration rather than testing. The F-16 program might support this contention. The F-16 SAMTs have experienced very few failures and minimum downtime.

MIL-T-81821, paragraph 4.2.4.4 suggests the following for reliability tests.

> "Reliability tests shall be required ... and shall be subject to the following criteria:
>
> (a) Monitoring instruments shall be used to observe essential operating characteristics and to determine the time of failure.
>
> (b) A failure shall be considered to have occurred whenever the training device requires corrective maintenance action in order to perform its function within specified limits.
>
> (c) A pattern failure shall be considered to have occurred when two or more failures of the same part in identical or equivalent application exceeds their combined predicted failure rate. Necessary corrective action at no cost to the Government shall be required, including retrofitting of equipment already accepted under the same contract."

Regarding the conditions of the reliability test, along with the specification of the time duration of the reliability test, consider the following:

> "The test shall consist of a number of test periods in accordance with a list of training exercises. The training exercises should be similar to the actual training use of the device. The test periods are to be arranged to cycle the equipment to provide cool-down periods and restarts representative of actual usage.

During the off periods, for cool-down, the planned and permissible preventive maintenance schedule may be followed. If the time lost for unscheduled repair during the planned test (course) period requires that additional test time be expended to complete the planned test, such time will not count as operational on-time. The summations of the satisfactory operational on-times and planned training times will be substituted into the model described herein to determine compliance with the scheduled availability.

The duration of the test shall be one complete training course unless otherwise stated in the detail specification."

It should be noted, then, that the availability test is a functional reliability test.

Maintainability Tests. For maintainability verification, MIL-T-81821 (paragraph 4.2.4.4.1) specifies the following:

"The contractor shall verify that all parts and components are identifiable in the Illustrated Parts Breakdown and are readily accessible for servicing and replacement, and that all maintenance repair and set-up instructions in the MOMI are complete and valid."

It should be noted, as specified before, there must be complete coordination between the special and specific tests and the Data Item Descriptions specified in the contract.

If maintainability is going to be determined through demonstration rather than tests, then the fo'lowing may be specified:

"The demonstration shall be conducted by Government personnel who have successfully completed the on-site contractor-conducted training program, using only those tools, equipment, data, training personnel and material resources which have been programmed and provided as a result of the trainer contract. Conduct of the demonstration shall be predicated upon the natural operation of the trainer during training situations. However, if natural operation of the trainer does not result in a conclusive accept or reject decision, simulated failures may be used to supplement actual failures in order to arrive at a conclusion (subject to approval of the Procuring or Contracting Officer).

(a) Contractor participation during conduct of the demonstration shall be limited to the following:

    (1) Preparation of demonstration plan.

    (2) Training cognizant demonstration personnel in the objectives of the program and the techniques which will be used to gather required data.

    (3) Observation of demonstration tests, recording all data and preparation of Maintainability Demonstration Report.

(b) Government participation during conduct of the demonstration will include the following:

    (1) Conduct of maintainability demonstration.

    (2) Performance of maintenance services during the demonstration period."

<u>Software (Computer Program) Tests:</u> This is a rather critical area if the maintenance trainer is computer driven. MIL-T-81821 does not say anything specific about the testing of software or computer programs. ATC has developed a checklist, <u>ATC Training Equipment Acceptance Demonstration Checklist</u> (ATC Form 514), which contains a section (Section H) on software and suggests the following characteristics be verified during the quality assurance program:

"1. Training magnetic media identification is compatible with computer program user's manual."

"2. Diagnostic software is available for troubleshooting and maintenance (may want to add that software is available for creating new exercises)."

"3. Magnetic media has adequate and accessible storage."

"4. Perform an operational check and qualitative assessment of software following applicable Technical Orders to ensure that:

- Design malfunctions can be inserted effectively by use of instructional software.

- Trainer, within practical limits, simulates authentically the operational procedures/ responses of the weapon system and support equipment.

- Operational range of all displays are within the tolerance specified and are verified during test and calibration.

- Sequence switches, latches, and push buttons operate freely and engage properly as verified during daily readiness test.

- Cathode Ray Tube (CRT) displays are checked for linearity, brightness, focus, jitter, and legibility.

- Audio generating equipment (tones/voice) is intelligible and has sufficient adjustable audio."

It should be pointed out that the above are appropriate if a demonstration is conducted. MIL-STD-483, although dealing primarily with configuration management, provides some insights for specifying tests for computer programs (software), as well as some criteria for conducting the Functional Configuration Audit (FCA) and the Physical Configuration Audit (PCA) for computer programs. First, let us review what MIL-STD-483 says about Category I tests for the computer programs. In the quote below, CPCI refers to the Computer Program Configuration Identification (CPCI). The references given to the paragraph numbers refer to the paragraph number within MIL-STD-483 and not those within this Handbook. MIL-STD-483, paragraph 60.4.4.1.1 (page 45) states the following:

> "The term 'category I test' as used herein is defined to include all testing of the CPCI other than that accomplished during the formal category II (or equivalent) system/configuration item test programs. (See paragraph 4.1.5 below.) Category I testing is subdivided into the following broad types:
>
> a. Computer programming test and evaluation - Tests conducted prior to and in parallel with preliminary or formal qualification tests. These tests are oriented primarily to support the design and development process.

b. Preliminary qualification tests - Formal tests oriented primarily towards verifying portions of the CPCI prior to integrated testing/formal qualification tests of the complete CPCI (see paragraph 4.1.3 below). These tests will typically be conducted at the contractor's design and development facilities.

c. Formal qualification tests - Formal tests oriented primarily towards testing of the integrated CPCI, normally using operationally configured equipment at the category II site prior to the beginning of category II testing. This testing will emphasize those aspects of the CPCI performance which were not verified by preliminary tests. The testing requirements which cannot be verified during category I testing will be specified in paragraph 4.1.5.

NOTE: Requirements for verification included in the system/system segment specification, which are directly related to requirements specified herein, may be incorporated herein in reference to avoid redundant establishment of the requirements."

Discussions with military software engineers support the approach presented in MIL-STD-483; i.e., these discussions indicated the following:

- During design and development, the computer program modules are checked for structure. Also, during design and development, any computer manufacturer-supplied programs are informally tested. (This would include the operating system programs, etc.) Documentation of the manufacturer supplied programs are also checked and verified.

- During the preliminary qualification testing phase, individual or module programs are tested. They are <u>not</u> tested for integration (e.g., dummy "calls" may be inserted to see if the program functions properly). Typically, the module programs are tested when the contractor or vendor notifies the Air Force that such programs have been developed.

- During formal qualification testing, the integration of the programs is tested; i.e., a check is made to see if programs work together (e.g., pass information from one program to another). Also, an operational test is included. Typically, this test is performed in the simulated training environment. The programs are verified

to see if they produce the desired training results. In addition, if different parameters can be entered, they are checked. In this way, different "paths" through the software can be verified.

In addition, it is important to verify the support programs, the diagnostic programs, and the instructional features software. Typically, these are checked by running and using them in the operational mode. In addition to a software engineer, an instructor should take part in the verification of the software, particularly during the operational test. After all, it is the instructor who will be required to interact with the software once it is delivered and initialized.

MIL-STD-483 says very little about category II tests for computer programs. MIL-STD-483 (page 47) simply says:

> "... requirements specified in section 3 which cannot be verified until category II testing (or equivalent) ... must be listed as category II test requirements."

MIL-STD-483, paragraphs 120.6 and 120.6.1 (pages 96 and 97) says the following about the functional configuration audit for computer programs:

> "The primary product of the FCA is to verify the completion of all the tests required by the development part (1) specifications. The FCA is the preparatory informal audit leading to the scheduling of the PCA. The FCA is the culmination of other engineering reviews which are progressive review points in the development cycle.
>
> The FCA shall encompass the following:
>
> a. The configuration of the CI qualified (or to be qualified) as documented by released engineering for the CI unit to be audited shall be directly compared with the development specification requirements. Differences shall be made a matter of record and reflected in the minutes of the FCA for post audit action. The configuration for the article qualified (or to be qualified) shall be the same as that released for the article to be subjected to the physical configuration audit, modified only as required to permit installation of test instrumentation. Any other differences shall be recorded and evaluated prior to the beginning of the actual FCA. Performance analysis data and failure modes and

effects analysis data shall be reviewed where applicable if it is impracticable to establish achievement of a specified performance parameter through test data.

b. The validity of acceptance requirements, as specified in section 4 of the draft product specification for the CI, shall be verified by direct comparison of the test methods/procedures and test data (if required) with the performance/design requirements for the deliverable CI. The comparison shall be accomplished to the level of detail necessary to establish that the methods and instrumentation, as required by the contractor's internal test procedures, satisfy the product specification and are adequate to verify the performance quality of the CI. If changes to the acceptance testing as specified in the draft product specification prove to be necessary, the specification shall be changed prior to submittal of the product specification for the physical configuration audit.

c. Configuration items that do not require qualification testing shall have all requirements in the development specification verified during the FCA whether a point of qualification or not. This is accomplished by reviewing all category I/engineering test data and verifying that all design requirements have been met.

d. The contractor in cooperation with the procuring activity shall develop at the FCA a checklist for use at the PCA. The checklist shall identify documentation and hardware to be available and tasks to be accomplished."

For requirements concerning the physical configuration audit (PCA), MIL-STD-483 (pages 97 and 98) offers the following:

"The physical configuration audit (PCA) is a formal audit which verifies the documentation which establishes the product baseline for the configuration item. The primary product of the PCA is formal determination that the CI is built to the released engineering data and that the data included/referenced in the product specification adequately and accurately identifies the CI. This is accomplished by an audit which establishes the exact

relationship of the CI, as described by released engineering data to the unit manufactured and assembled (or for computer program CIs coded). The PCA establishes the validity of the production acceptance testing of the CI by direct comparison of the acceptance test methods and test data (if required) with the specified performance of the CI. The product specification for the CI, once audited at the PCA serves as the basic document for acceptance requirement and configuration control of subsequent deliveries of the CI during the acquisition phase. Normally, only one PCA shall be accomplished for each CI. A major engineering change, a manufacturing process change, or an indication that the configuration being produced does not accurately reflect released engineering data, may require reaccomplishment of the complete PCA. The PCA shall be accomplished at the contractor's facility where production of the CI is in progress, unless otherwise authorized by the procuring activity. An exception is computer programs in which case the PCA may be held at the category II test site immediately prior to the start of category II or equivalent system testing. The PCA on hardware CIs shall be conducted on the first production article of the CI scheduled for category II or equivalent testing or the operational inventory whichever occurs first, after satisfactory completion of qualification of the CI to its development specification, unless otherwise specified by the procuring activity. Normally, the procuring activity will conduct the PCA jointly with the contractor and reserves the prerogative to have representatives of the procuring activity accomplish all or any portion of the required audits, inspections, and tests.

The checklist which was developed at the FCA shall be used in conducting the PCA and may be modified as appropriate by agreement between the contractor and the procuring activity. The following shall be accomplished as a part of each PCA:

a. The configuration of the selected as-manufactured article of the CI shall be compared directly with the documented configuration of the same article as contained in the product specification, top assembly drawing, and other released engineering data. For hardware CIs, part numbers and serial numbers of the selected CI and included components shall be compared directly with released engineering data and manufacturing records. The released engineering data for the selected article shall be the drawings

documents assembled by the top drawing number specified in the product specification. Differences between the configuration specified by the product specification and the as-manufactured configuration presented for audit shall be documented in the minutes of the audit.

b. For computer program CIs, identification markings, CPCI/CPC numbers, shall be compared directly with [the] version description document for the selected article (see appendix VIII). Differences between the technical description contained in the product specification and the article presented for audit shall be documented in the minutes of the audit.

c. The compatibility of the detail design of the CI with other interfacing system equipment/computer program/facilities shall be established by comparison of the released engineering data for the CI and the unit as manufactured, with the approved interface control drawings with which the CI is associated.

d. Drawings to be used at the PCA shall be those released to manufacturing for the CI. However, there shall be no more than five outstanding EOs or equivalent change forms per drawing.

e. For computer program CI's, descriptive documentation (i.e., program instruction listings, flow charts) contained in the product specification used at the PCA shall have all approved changes incorporated, except when mutually agreed by the contractor and the procuring activity.

f. The contractor's engineering release system and change control procedures shall be reviewed and validated against the requirements in appendix IX."

In summary, it would appear that specific or special tests are not really indicated for the computer programs. Configuration audits are usually performed only if a computer program specification is required by a DID. However, it should be realized that spare capacity and growth should be verified. Subparagraphs 3.7.2.2.1.5, 3.7.2.3.1.3, and their subparagraphs of this Handbook discuss spares and growth, while 3.7.2.2.2.4.5, 3.7.2.3.2.3, and their subparagraphs specify spare verification

Although no specific tests or special tests are indicated for software, the preparer may find it useful to specify, in this subparagraph, the basic strategy for testing the software. The following wording might be used for this purpose:

> "Computer programs shall be verified in stages. Module programs shall be verified individually as they are developed by the contractor or vendor. When all individual programs have been verified, the integration of the progress shall be tested. All software (including support and diagnostic software) shall be operationally tested. Parameters shall be input to verify output ranges. Student response paths shall also be verified."

Other specific tests and special tests will now be discussed.

Human Factors Compliance Tests. MIL-T-81821, subparagraph 4.2.4.1 states the following:

> "Each trainer panel shall be tested from a training effectiveness standpoint to demonstrate that training requirements are satisfied, and to assure compliance with the human factor requirements of MIL-STD-1472."

This wording should be used only if MIL-STD-1472 was set as a requirement in subparagraph 3.3.7 of the Prime Item Development Specification. Human factors demonstrations or tests may not be appropriate in every situation. It may also be possible to integrate the human factors compliance test with other tests, such as the operational test; i.e., a separate test solely for human factors compliance may not be required.

Other specific or special tests which the preparer might consider specifying are Electromagnetic Interference Suppression Tests and Environmental Tests. Each of these is discussed below:

Electromagnetic Interference Suppression Tests. Typically, a maintenance trainer will not require that such tests be performed. In addition, such tests normally require special test equipment. Furthermore, these tests are expensive to perform.

MIL-T-81821, paragraph 4.4.2.2.9 states the following:

> "The electronic trainer panels shall be tested to determine conformance to the electromagnetic interference suppression requirements of paragraph 3.3.2 herein,

by means of the applicable test methods specified in MIL-STD-462, for Class 1D equipments which are concerned with conducted and radiated electromagnetic emissions, and with degradation of performance of equipment due to susceptibility to electromagnetic interference."

Environmental Tests. The following may be specified:

"Environmental tests shall be performed as necessary to establish durability and reliability of the training device materials and components under specified environmental operating conditions. These tests shall be those required by the detail specification and shall be in accordance with MIL-STD-810."

In this particular application, a detailed specification may not have been prepared and, therefore, reference to such a specification can be deleted.

The remainder of the tests specified in MIL-T-81821 are not described in sufficient detail. However, for completeness, the preparer should consider the following kinds of tests:

- Temperature Measuring (see MIL-T-81821, paragraph 4.2.4.2.5).
- Controls and Control Circuits (see MIL-T-81821, paragraph 4.2.4.5.2).
- Functional Test (see MIL-T-81821, paragraph 4.2.4.5.3).
- Structural Test (see MIL-T-81821, paragraph 4.2.4.5.4).
- Power Test (see MIL-T-81821, paragraph 4.2.4.5.5).
- Electrical Tests.
- Grounding and Grounding System Tests.

Background and Sources: Sources are identified in the Performance Parameters section.

Lessons Learned: It is difficult to determine what special tests or specific tests should be required. Often the tests required depend upon the nature and type of trainer being proposed.

It seems reasonable to suggest that the need for reliability and maintainability tests depends upon the sophistication of the trainer, as well as upon the amount of off-the-shelf material and

components that are to be used in constructing the trainer. If the trainer is using commercially available components, it may be reasonable to keep the reliability and maintainability tests to a minimum. If the trainer is relatively sophisticated, then perhaps more sophisticated test requirements should be established. Regardless of the nature or extent of the reliability and maintainability tests, it is important for the preparer to specify the conditions of the tests. That is, in this subparagraph the preparer should:

- Describe the test procedure.
- Describe the time duration of the test.
- Describe when the test will take place.
- Describe the test equipment which will be used.
- Describe computational procedures.

Again, it should be realized that the extent of reliability and maintainability testing depends upon the level of sophistication of the trainer.

Verification of the software should also be given careful consideration in this subparagraph. A review of Military Standards and Specifications revealed that no special tests were indicated except for spares and growth. However, it seems reasonable to suggest that the software should be monitored as it is developed. It also seems reasonable to separate the monitoring into two separate phases. In Phase I, individual program modules should be verified as they are developed. During Phase II, the integration of the individual program modules should be verified. Software can be verified best during the operational test. The trainer and the software should be run as if an actual training exercise were being performed by the student. All the training or instructional features should be used and applied. The operational test should involve Air Force personnel; i.e., the contractor or vendor should be there only for assistance, if needed. People experienced in conducting quality assurance tests have indicated that most of the "problems" with the trainer are discovered when the trainer is used in a free-play mode or the T.O. mode (T.O. mode refers to verifying that the trainer tracks or follows the T.O.s). Also, during the free-play mode, the tester can act as a student and enter responses which might be entered by an uninformed student.

The electromagnetic interference suppression test should not be performed unless absolutely needed. These tests tend to be relatively expensive. Often the contractor or vendor must obtain the services of an outside firm to conduct such tests.

The remaining tests are difficult to discuss. Their application is dependent upon unique situations. For example, environmental

tests might be needed if the trainer is going to be used in an extreme environment (e.g., a cold climate). Thus, the preparer should use his or her own judgment in specifying the tests recommended in this section.

4.2 VERIFICATION CROSS-REFERENCE INDEX.

"Verification Cross-Reference Index: Verification shall be accomplished by inspection, analysis, demonstration, or test, or a combination thereof, as defined below:

a. Inspection. Inspection is defined as a visual verification that the unit as manufactured conforms to the documentation to which it was designed.

b. Analysis. Analysis is defined as verification that a specification requirement has been met by technical evaluation of equations, charts, reduced data and/or representative data displays.

c. Demonstration. Demonstration is a method of verification denoting the qualitative and quantitative determination of the properties and parameters (or components thereof) by means which do not necessarily require the use of laboratory equipment, procedures, items, or services to verify conformance to specified requirements.

d. Test. Test is defined as verification that a specification's requirement is met by thorough exercising of the applicable training equipment under appropriate conditions in accordance with applicable performance checkout and test procedures. Testing normally requires instrumentation.

The following table establishes the method of verification/qualification to be applied: ______________________________
____
____."

Rationale and Guidance: In this subparagraph the preparer is to insert Table 2, the Verification Cross-Reference Index. The cross-reference index indicates how each of the requirements in section three of the specification is to be verified. Each paragraph and subparagraph in section 3 must be verified. It makes no sense to establish a requirement in section 3 unless the requirement is going to be verified in the finished product. Thus, it is important that each requirement in section 3 be listed within the proposed table. (Note: Within the completed Prime Item Development Specification, the VCRI will probably be numbered Table 1).

Performance Parameters: A sample verification index is provided below. It should be noted that some of the requirements can be verified using different verification methods. A review of

Table 2. Sample VCRI.

PARAGRAPH NUMBER	INSPECTION	ANALYSIS	DEMONSTRATION	TEST	NOT APPLICABLE (Will Not Be Verified)
3.0					X
3.1	X		X		
3.1.1	X				
3.1.2	X	X			
3.1.3	X	X	X		
3.1.4					X
3.1.5					X
3.2					X
3.2.1					X
3.2.1.1					X
3.2.1.2		X	X		
3.2.1.3		X	X		
3.2.1.3.1					X
3.2.1.4					
3.2.1.4.1	X	X	X	X	
3.2.1.4.2	X	X	X	X	
3.2.1.4.3		X			
3.2.1.5					X
3.2.1.5.1			X	X	
3.2.1.5.2		X	X		
3.2.1.5.3			X		
3.2.1.5.4		X	X		
3.2.1.5.5		X	X		
3.2.1.5.6		X	X		
3.2.1.5.7				X	
3.2.1.5.8		X	X	X	
3.2.1.5.9			X		
3.2.1.6					X
3.2.1.7					X
3.2.2					X
3.2.2.1		X		X	
3.2.2.2	X	X			
3.2.2.3				X	
3.2.2.4	X				
3.2.2.5	X	X	X		
3.2.2.6	X	X	X	X	
3.2.2.7	X				
3.2.2.8				X	
3.2.2.9					X
3.2.3		X			
3.2.4		X			
3.2.4.1		X			
3.2.4.2		X			
3.2.4.2.1		X		X	
3.2.4.3		X	X	X	
3.2.5				X	
3.2.5.1				X	
3.2.6	X				
3.2.6.1	X				
3.2.7					X
3.2.7.1					X
3.3					X
3.3.1		X			
3.3.1.1		X			
3.3.1.1.1		X			
3.3.1.1.1.1		X			
3.3.1.1.1.2		X			
3.3.1.2	X	X			
3.3.1.3	X	X			
3.3.1.4	X				
3.3.1.5	X	X		X	
3.3.1.6					X
3.3.1.6.1		X		X	
3.3.1.6.1.1				X	
3.3.1.6.2		X		X	
3.3.1.6.3		X		X	
3.3.1.6.4		X		X	
3.3.1.6.5		X	X		

Table 2. Sample VCRI. (Continued)

PARAGRAPH NUMBER	INSPECTION	ANALYSIS	DEMONSTRATION	TEST	NOT APPLICABLE (Will Not Be Verified)
3.3.1.6.6	X	X		X	
3.3.1.6.7		X		X	
3.3.1.6.8		X		X	
3.3.1.6.9		X			
3.3.1.6.9.1	X	X		X	
3.3.1.7	X	X			
3.3.1.8	X		X		
3.3.1.9		X			
3.3.1.10	X	X	X	X	
3.3.1.11	X	X	X		
3.3.2				X	
3.3.3	X				
3.3.3.1	X				
3.3.3.2	X	X			
3.3.3.3	X				
3.3.3.4	X				
3.3.3.5	X				
3.3.3.6	X				
3.3.3.7	X				
3.3.3.8	X	X			
3.3.4		X		X	
3.3.5		X			
3.3.6		X		X	
3.3.6.1				X	
3.3.6.2		X		X	
3.3.6.2.1		X	X	X	
3.3.6.2.2		X	X	X	
3.3.6.3		X		X	
3.3.6.4		X			
3.3.6.5		X		X	
3.3.6.6		X		X	
3.3.6.7					X
3.3.6.7.1		X		X	
3.3.6.7.2		X		X	
3.3.6.8		X		X	
3.3.7		X	X	X	
3.4		X			
3.5					X
3.5.1		X			
3.5.2		X			
3.5.3		X	X		
3.6					X
3.6.1					X
3.6.2					X
3.7	X	X	X		
3.7.1		X			
3.7.1.1		X	X		
3.7.1.2		X	X		
3.7.1.3		X	X		
3.7.1.4		X	X		
3.7.1.5	X	X			
3.7.2					X
3.7.2.1		X	X	X	
3.7.2.1.1		X		X	
3.7.2.1.1.1		X		X	
3.7.2.1.1.2	X				
3.7.2.1.2		X			
3.7.2.1.2.1		X			
3.7.2.1.2.2		X			
3.7.2.1.2.2.1		X	X		
3.7.2.1.2.2.2		X	X		
3.7.2.1.2.2.3		X	X		
3.7.2.1.2.3	X				
3.7.2.2					X
3.7.2.2.1	X				
3.7.2.2.1.1		X		X	

Table 2. Sample VCRI. (Continued)

PARAGRAPH NUMBER	INSPECTION	ANALYSIS	DEMONSTRATION	TEST	NOT APPLICABLE (Will Not Be Verified)
3.7.2.2.1.1.1		X		X	
3.7.2.2.1.1.2		X		X	
3.7.2.2.1.1.3		X		X	
3.7.2.2.1.1.4		X		X	
3.7.2.2.1.1.5		X		X	
3.7.2.2.1.1.6		X		X	
3.7.2.2.1.2		X		X	
3.7.2.2.1.3		X		X	
3.7.2.2.1.4		X		X	
3.7.2.2.1.4.1		X		X	
3.7.2.2.1.4.1.1		X			
3.7.2.2.1.4.1.2		X			
3.7.2.2.1.4.2					X
3.7.2.2.1.4.2.1		X	X	X	
3.7.2.2.1.4.2.2		X	X		
3.7.2.2.1.4.3		X	X	X	
3.7.2.2.1.4.4		X		X	
3.7.2.2.1.5		X		X	
3.7.2.2.1.5.1		X		X	
3.7.2.2.1.5.2		X		X	
3.7.2.2.1.5.3	X	X		X	
3.7.2.2.1.5.4	X	X			
3.7.2.2.1.5.5	X	X			
3.7.2.2.1.5.6		X		X	
3.7.2.2.2		X			
3.7.2.2.2.1		X		X	
3.7.2.2.2.1.1		X		X	
3.7.2.2.2.1.2		X	X	X	
3.7.2.2.2.2		X		X	
3.7.2.2.2.3		X			
3.7.2.2.2.3.1		X		X	
3.7.2.2.2.3.2	X				
3.7.2.2.2.4		X	X	X	
3.7.2.2.2.4.1		X	X	X	
3.7.2.2.2.4.2		X	X	X	
3.7.2.2.2.4.2.1		X		X	
3.7.2.2.2.4.2.2		X	X	X	
3.7.2.2.2.4.3		X		X	
3.7.2.2.2.4.4		X		X	
3.7.2.2.2.4.5		X	X	X	
3.7.2.2.2.4.5.1		X	X	X	
3.7.2.2.2.4.5.2		X		X	
3.7.2.2.2.4.6	X				
3.7.2.3		X			
3.7.2.3.1	X	X			
3.7.2.3.1.1		X			
3.7.2.3.1.1.1		X		X	
3.7.2.3.1.2		X		X	
3.7.2.3.1.2.1		X		X	
3.7.2.3.1.2.2		X	X		
3.7.2.3.1.2.3		X		X	
3.7.2.3.1.2.4		X		X	
3.7.2.3.1.3		X			
3.7.2.3.1.3.1		X		X	
3.7.2.3.1.3.2	X	X		X	
3.7.2.3.1.3.3		X			
3.7.2.3.1.4		X		X	
3.7.2.3.2		X	X	X	
3.7.2.3.2.1		X	X	X	
3.7.2.3.2.2		X		X	
3.7.2.3.2.3		X	X	X	
3.7.2.3.2.3.1		X		X	
3.7.2.3.3		X		X	
3.7.2.3.3.1		X			
3.7.2.3.3.2		X			
3.7.2.3.3.3		X			
3.7.2.3.3.4		X		X	
3.7.2.3.3.5		X	X		

Table 2. Sample VCRI. (Continued)

PARAGRAPH NUMBER	INSPECTION	ANALYSIS	DEMONSTRATION	TEST	NOT APPLICABLE (Will Not Be Verified)
3.7.2.3.3.6		X			
3.7.2.3.3.7		X		X	
3.7.2.3.4	X				
3.7.2.3.4.1	X				
3.7.2.3.4.2	X				
3.7.2.3.5		X			
3.7.2.3.5.1					X
3.7.2.3.5.1.1		X		X	
3.7.3	X	X	X	X	
3.8					X

maintenance trainer specifications indicated that the following wording might be added after the insertion of the VCRI Table:

> "In those cases where a section 3 requirement is to be verified by two or more methods, formal qualification will not be considered complete until the highest level of verification has been accomplished."

Background and Sources: The verification index is not a requirement. However, it does seem to be an efficient way to present the information. As an alternative, one of two approaches can be taken:

- Each subparagraph in section 3 can have a corresponding subparagraph in section 4.

- The VCRI can be presented along with a corresponding subparagraph in section 4 for each subparagraph in section 3.

Lessons Learned:

5.0 PREPARATION FOR DELIVERY.

"Unless otherwise specified in the contract or order, preparation for delivery of the maintenance trainer shall be: ______________________________ ______________________________."

Rationale and Guidance: When completing this section, consider the following:

a. Method of transportation (e.g., air carrier).

b. Packing (e.g., covers shall provide adequate protection to comply with the method of transportation).

c. Base (specify requirements for lifting).

d. Markings.

e. Preparation for shipping (e.g., removal of fluids and fuels).

Performance Parameters: Many of the requirements for this subparagraph have been specified in other parts of the Prime Item Development Specification. The engineer should be careful to assure that the text provided for this subparagraph is consistent with other subparagraphs of the specification. Particular attention should be given to the following subparagraphs: 3.2.7, 3.2.7.1, 3.3.3.7, 3.3.3.8, and 3.7.

Background and Sources: Sources are specified above. Also see MIL-T-81821 for further clarification of the requested information.

Lessons Learned:

6.0 NOTES.

" ____."

<u>Rationale and Guidance</u>: MIL-STD-490, paragraph 10.6 (page 32) specifies the following:

> "The contents of this section are not contractually binding. Any information which may be made known as background information may be included herein."

Throughout the specification it has been noted that some information was included in section 3 which only provides the contractor or vendor with guidance. It would be appropriate to include some of this information in this subparagraph rather than in section 3.0, since section 3.0 is usually reserved for requirements and not guidance. For example, subparagraph 3.1.1 requests an item diagram to be inserted. Often the preparer will not have in mind a specific diagram which he or she is willing to let be a requirement; therefore, often the diagram that is provided is only a suggestion and not a firm requirement. Under these conditions, it may be more appropriate to place the item diagram in this section rather than in section 3. This may also be true for the interface definitions offered in subparagraph 3.1.2.

It should also be noted that some of the information in subparagraph 3.1 TRAINER DESCRIPTION (e.g., the information concerning the target population) might be placed within this section since a firm requirement is not being established. The purpose of supplying this information is to provide additional guidance to the contractor or vendor.

It is also appropriate, in the Notes section of the Prime Item Development Specification, to include the ISD-Based Training Equipment Design Specification generated by the ISD analysts. This document contains many training-related issues of which the contractor or vendor should be aware; i.e., it is the source for many of the requirements specified in the Prime Item Development Specification. In addition, many of the special tests indicated or specified in paragraph 4.0 of the Prime Item Development Specification depend upon the requirements specified in that document; e.g., it has been suggested that the operational test be conducted by externally using the ISD-derived information. If this is the case, then the ISD-Based Training Equipment Design Specification should be included in this paragraph.

Performance Parameters: Insert any information which would provide additional guidance to the contractor or vendor; e.g., suggested item diagrams, suggested interface definitions, the ISD-Based Training Equipment Design Specification.

Background and Sources: The NOTES paragraph is indicated by MIL-STD-490.

Lessons Learned:

APPENDIX A

INSTRUCTIONAL FEATURES DEFINITIONS

INSTRUCTIONAL FEATURES DEFINITIONS

Instructional Features

Instructional Features are devices or mechanisms on the trainer which control critical aspects of the learning environment, such as presentation of the stimuli, recording and scoring of responses, presentation of augmented feedback messages, and selection of the next activity in which the student is to be engaged. The interested reader should see Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation for complete and comprehensive descriptions and definitions of the instructional features presented below. It should be noted that the instructional features briefly discussed below are instructional features which can be automatically controlled (by computer), as well as manually controlled. Not included as instructional features are such things as the portability, noise level, etc. of the trainer. These features, although they increase the instructional utility of the trainer, are not usually under computer/processor control. As such, they are not represented below.

a. On-Off/Select Sensing. A control (or set of controls) on the trainer which allows the instructor to turn on or off the devices or mechanisms which sense the student's response(s) or to select only those responses which are to be sensed for a given student exercise. On-Off/Select Sensing can be computer/processor-controlled. Notice that a response that is sensed by the trainer is not necessarily recorded by the trainer. See the next instructional feature.

b. On-Off/Select Recording. A control (or set of controls) on the trainer which allows the instructor to turn on or off the devices or mechanisms which record the response(s) of the student or allows the instructor the opportunity to select only those student responses which are to be recorded for a given exercise. The recording of student responses can be computer/processor-controlled. A response that is recorded by the trainer is not necessarily scored by the trainer (see the next instructional feature). All responses recorded by the trainer, however, must be sensed by the trainer.

c. On-Off/Select Scoring. A control (or set of controls) which allows the instructor to turn on or off the devices or

mechanisms which score the recorded responses or to select only those recorded responses to be scored for a given exercise. The scoring function permits the student response to be compared to an acceptable response. The scoring function is typically computer/processor-controlled.

d. <u>On-Off/Select Reporting</u>. A control (or set of controls) on the trainer which allows the instructor to turn on or off the devices or mechanisms which report student response(s) and/or score(s) or allows the instructor to select what response(s) and/or score(s) are to be reported. This instructional feature requires a reporting device, such as a computer/processor-controlled printer.

e. <u>On-Off/Select Monitoring</u>. A control (or set of controls) on the trainer which allows the instructor to turn on or off the devices or mechanisms which monitor the status of the controls and/or displays of the system or subsystem being simulated or to select which controls and/or displays are to be monitored for a given exercise. All system displays and/or controls which are monitored by the trainer are typically sensed, recorded, and reported by the trainer.

f. <u>Reporting Devices</u>. A device (or set of devices) used to report student responses and/or scores and/or the status of the system being simulated. Reporting devices are used only if the trainer is reporting responses, scores, or the system status to the instructor and/or student. Reporting devices can be used to report system status, student responses, or student scores separately and/or collectively.

g. <u>Storage Devices</u>. A device (or set of devices) used to store student responses, scores, and/or the status of the system being simulated for future retrieval (e.g., for diagnostic purposes or for planning future next activities for the student). Storage devices, as used in this specification, are either hardcopy (e.g., printouts which are filed in a convenient manner) or electronic devices (e.g., diskettes, magnetic tape, hard disks, etc.).

h. <u>Adjustable Criteria Control</u>. A control (or set of controls) on the trainer which allows the instructor to adjust (change or modify) the value to which student responses are compared during scoring. This control (or set of controls) is appropriate only if the trainer is automatically scoring student responses; i.e., has instructional feature <u>c</u>, above.

i. On-Off/Select Feedback. A control (or set of controls) on the trainer which allows the instructor to turn on or off the devices or mechanisms that provide the student with augmented feedback messages or to select the time or schedule of the augmented feedback message given to the student during a given exercise presented by the trainer. Typically, these messages will appear on a CRT or a printer and, thus, will be computer-controlled. The control or set of controls would disable the device or devices that provide or present the feedback messages.

j. Feedback Message Adjust Control. A control (or set of controls) or device(s) which allows the instructor to adjust (change or modify) the augmented feedback message that is given to the student during a given exercise. This control or device allows the instructor to create new messages. This instructional feature usually appears with instructional feature i, above.

k. Rate Adjust Control. A control (or set of controls) on the trainer which allows the instructor to adjust (change or modify) the rate at which stimuli are presented to the student during a given exercise. In essence, this control allows the instructor to control the rate or speed at which the exercise is presented to the student.

l. Signal-to-Noise Adjust Control. A control (or set of controls) on the trainer which allows the instructor to adjust (change or modify) the ratio of signal to noise for a given exercise. Exercises may be influenced by the amount of true signal to the amount of true noise. Typically, beginning students, to learn, must have a strong signal with little noise. As the student progresses through the training, the instructor may wish to present exercises which contain a lot of noise and a minimum amount of signal. This control allows the instructor to control the strength of the signal relative to the strength of the noise.

m. Cue Enhancement Control. A control (or set of controls) on the trainer which allows the instructor to highlight (magnify, intensify, or otherwise make more noticeable) a stimulus or response for a given exercise. The control can be an on-off control where all stimuli or responses are highlighted, or a select control where the instructor can select which stimulus or response is to be highlighted for a given exercise. This control would be used to permit the instructor to set the trainer for students who are at various stages of learning. Students who are in the early stages of learning may need more highlighting than do students who are in the later stages of learning.

n. Malfunction Insertion Control. A control (or set of controls) on the trainer which allows the instructor to select a malfunction which has been pre-programmed into the trainer. This control (or set of controls) assumes that the trainer is programmable via a computer/processor.

o. System Parameter Control. A control (or set of controls) on the trainer which allows the instructor to pre-set (before the exercise begins) a system parameter value or allows the instructor to input system parameter values during the exercise. The control can be used to make operational a malfunction condition, providing the system parameter being altered signifies a malfunction condition. It is the kind of instructional feature that allows the instructor to create new exercises for the student; i.e., does not limit the instructor to using pre-programmed student exercises.

p. On-Off/Select Next Activity. A control (or set of controls) on the trainer which allows the instructor to turn on or off the next activity pre-programmed for the student or allows the instructor to select the next activity from a list of pre-programmed next activities. This control over the learning environment is typically computer-controlled.

q. On-Off Freeze. A control (or set of controls) on the trainer which allows the instructor to turn on or off the pre-programmed freeze instructions within the trainer or to freeze the trainer in a given state when a freeze is not pre-programmed. A freeze shall cause all displays, controls, indicators, etc. to remain fixed in their positions at the moment of the freeze.

APPENDIX B

SOURCES AND REFERENCES USED IN THE PREPARATION OF HANDBOOK (SECTION III)

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
1.0 Scope		
1.1 General	1.2a	
1.2 Application		
1.3 Deviation		
2.0 Applicable Documents		
2.1a Issue of Documents		MIL-STD-490 (Page 33)
2.1b Issue of Documents	See 1.5 for list of references used in preparation of ISD-derived training equipment design	
2.2 Availability of Documents		
3.0 Requirements		
3.1a Trainer Description	2.2a, also see paragraphs 2.3, 2.3.1, 2.3.2 and 2.3.3, which further describe the target population	
3.1b Trainer Description	2.2c	
3.1c Trainer Description	2.2b	
3.1d Trainer Description	1.2b	
3.1e Trainer Description	3.2, 3.2.1.2a, 3.2.1.2b, 3.2.1.2c and 3.2.1.2d	
3.1f Trainer Description	For student station see 5.3, 5.3.1, 5.3.2; Instructor station see 5.4, 5.4.1, 5.4.2; Also see 3.3.3, 3.3.4, 4.2.1 and 6.2	AFHRL-TP-84-49 paragraph 2.1.4
3.1.1 Item Diagram(s)		For an example diagram see Specification No. 16 PSO 28A Figure 3-1; MIL-STD-490 (Page 33) further clarifies intent and content of this paragraph
3.1.2 Interface Definition(s)		Intent and content of this paragraph are clarified in MIL-STD-490 (Page 33). Also see AFHRL-TP-84-49 paragraph 2.2.4 and 2.2.11
3.1.3 Major Component List	See 1.4 for definitions of instructional features; Also see 5.0, 5.1, 5.2, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.2.9, 5.4, 5.4.1 and 5.4.2 for specific component of instructor station; Also see 4.2.2, 4.2.3 and 4.4 for specific components of student stations. For number of stations requested see 5.3, 5.3.1, and 5.3.2	AFHRL-TP-84-49 paragraph 2.5.5
3.1.4 Government Furnished Property List	3.3.3, 4.2.1, 4.2.2, 4.2.3, 4.3.1.1, and 4.4	MIL-STD-490 (Page 34); For categories of government furnished items see MIL-T-81821 (Page 8). Also see AFHRL-TP-84-49 paragraph 2.1.8
3.1.5 Government Loaned Property List		MIL-STD-490 (Page 34)
3.2 Characteristics		
3.2.1 Performance		
3.2.1.1 Training Objectives	2.5	MIL-STD-490 and MIL-T-81821; AFHRL-TP-84-49 paragraph 2.1.9

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.2.1.2 Tasks to be Trained	2.4.1	For task guidelines see AFP 50-58, Vol. II (Pages 2-10 to 2-12); For an example of a completed form see Specification No. 18PSO39B; Also see MIL-STD-490 and MIL-T-81821 for further clarification
3.2.1.3 Malfunctions to be Simulated	2.4.2; For further malfunction creations see 3.2.1.3	AFP 50-58, Vol. II (Chapters 2 and 3); MIL-STD-490 paragraph 20.3.2.1; MIL-T-81821 paragraph 3.2.1.1
3.2.1.3.1 Maintenance Concept of Operational Equipment		
3.2.1.4 Fidelity Levels		AFHRL-TP-84-49 paragraph 2.7.1
3.2.1.4.1a Fidelity Levels of Simulated Equipment	4.3.1 and 4.3.1.1	MIL-STD-490 paragraph 20.3.2.1; MIL-T-81821 paragraph 3.2.1.1
3.2.1.4.1b Fidelity Levels of Simulated Equipment		
3.2.1.4.2 Environmental Fidelity	3.3.1, 3.3.2, 4.3.2, 6.2 and 6.3; For possible job aids to be used by the student see 3.3.3 and 3.3.4	AFHRL-TP-84-49 paragraph 2.4.9
3.2.1.4.3a Probable Engineering Changes		
3.2.1.4.3b Probable Engineering Changes	See 4.3.3 for list of possible changes	AFHRL-TP-84-49 paragraph 2.7.11
3.2.1.5 Instructional Capabilities		AFHRL-TP-84-49 paragraph 2.1.7
3.2.1.5.1a Initialization and Warm-Up	3.2.1.1a	
3.2.1.5.1b Initialization and Warm-Up	3.2.1.1b	
3.2.1.5.1c Initialization and Warm-Up	3.2.1.1c	
3.2.1.5.2a Malfunction Exercise Selection	5.2.2a	
3.2.1.5.2b Malfunction Exercise Selection	5.2.2b	
3.2.1.5.2c Malfunction Exercise Selection		
3.2.1.5.3 Monitoring Student Performance	5.2.5	
3.2.1.5.4a Freeze Capability	5.2.1a	
3.2.1.5.4b Freeze Capability	5.2.1d	
3.2.1.5.5 Augmented Feedback Capability	5.2.6	
3.2.1.5.6 Next Activity Control Features	5.2.7	
3.2.1.5.7a Stimulus Control Features	5.2.8a	
3.2.1.5.7b Stimulus Control Features	5.2.8b	
3.2.1.5.8 Cue Enhancement Control Features	5.2.9	
3.2.1.5.9a Sign-In Capability		
3.2.1.5.9b Sign-In Capability	5.2.3b	
3.2.1.6 Utilization	3.3.2a and 3.3.2b	MIL-STD-490 paragraph 20.3.2.1b
3.2.1.7a Useful Life/Operational Service Life		MIL-STD-490 paragraph 20.3.2.1b

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.2.1.7b Useful Life/Operational Service Life		MIL-STD-490 paragraph 20.3.2.1b
3.2.1.7c Useful Life/Operational Service Life		MIL-STD-490 paragraph 20.3.2.1b
3.2.2 Physical Characteristics		
3.2.2.1a Weight Limits		MIL-T-81821 paragraph 3.2.2.2 and 3.7.2.1; MIL-STD-490 paragraph 20.3.2.2a; AFHRL-TP-84-49 paragraph 2.2.3
3.2.2.1b Weight Limits		MIL-T-81821 paragraphs 3.2.2.2 and 3.7.2.1; MIL-STD-490 paragraph 20.3.2.2a; AFHRL-TP-84-49 paragraph 2.2.3
3.2.2.2a Physical Dimensions		MIL-T-81821 paragraphs 3.2.2.2 and 3.2.2.2.1; MIL-STD-490 paragraph 20.3.2.2b; AFHRL-TP-84-49 paragraphs 2.2.2 and 2.2.6
3.2.2.2b Physical Dimensions	6.3	MIL-T-81821 paragraphs 3.2.2.2 and 3.2.2.2.1; MIL-STD-490 paragraph 20.3.2.2b
3.2.2.3a Moments		MIL-T-81821 paragraph 3.2.2.2.2; MIL-STD-490 paragraphs 20.3.2.2d and e
3.2.2.3b Moments		MIL-T-81821 paragraph 3.2.2.2.2; MIL-STD-490 paragraphs 20.3.2.2d and e
3.2.2.4 Work and Storage Areas		MIL-T-81821 paragraph 3.2.2.3; MIL-STD-490 paragraph 20.3.2.2
3.2.2.5 Attachment of Components		MIL-T-81821 paragraph 3.2.2.4; MIL-STD-490 paragraph 20.3.2.2
3.2.2.6 Other Dimensions and Tolerances		MIL-T-81821 paragraphs 3.2.2.5 and 3.2.2.3; MIL-STD-490 paragraph 20.3.2.2
3.2.2.7 Other Physical Properties		
3.2.2.8 Security Provisions		MIL-STD-490 paragraph 20.3.2.2f
3.2.2.9 Health and Safety		
3.2.3a Reliability		AFHRL-TP-84-49 paragraph 2.5.4
3.2.3b Reliability		
3.2.3c Reliability		
3.2.3d Reliability		Select applicable paragraphs from the following, which are appropriate to current application: MIL-STD-781C; MIL-STD-785A; MIL-STD-721A; MIL-STD-756A; MIL-STD-757; MIL-STD-781A; MIL-STD-781B; MIL-STD-778; MIL-STD-447 Do not make blanket use of these references
3.2.4a Maintainability		
3.2.4b Maintainability		
3.2.4c Maintainability		Select applicable paragraphs from: MIL-STD-470 and MIL-STD-471A; Also see MIL-STD-490 paragraph 20.3.2.4; MIL-T-81821 paragraph 3.2.4; AFHRL-TP-84-49 paragraph 2.5.3
3.2.4.1 Availability		MIL-T-81821 paragraphs 3.2.2 and 3.2.1.7
3.2.4.2a Fault Isolation		MIL-STD-490 paragraph 20.3.2.4

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.2.4.2b Fault Isolation		
3.2.4.2c Fault Isolation		
3.2.4.2.1a Isolation Requirements		
3.2.4.2.1b Isolation Requirements		MIL-T-81821 paragraph 20.3.2.4
3.2.4.2.1c Isolation Requirements		MIL-T-81821 paragraph 20.3.2.4
3.2.4.3 Built-In Tests, Self-Tests, and Diagnostic Tests		Specification No. 16PSO28A (Page 13), for an example
3.2.5a Environmental Conditions		MIL-STD-490 paragraph 20.3.2.5; MIL-T-81821 paragraph 3.2.5; MIL-T-81821E paragraph 3.2.1.5.1; AFHRL-TP-84-49 paragraph 2.2.7
3.2.5b Environmental Conditions		MIL-STD-490 paragraph 20.3.2.5; MIL-T-81821 paragraph 3.2.5; MIL-T-81821E paragraph 3.2.1.5.1
3.2.5.1 Other Environmental Conditions		MIL-STD-490 paragraph 3.2.5
3.2.6a Transportability	6.3	For mode of transportation see MIL-T-81821 paragraph 3.2.6; also see MIL-A-8421 and DOD Inst. 3224.1; AFHRL-TP-84-49 paragraphs 2.2.12a, b, c, d and 2.2.13a
3.2.6b Transportability		MIL-T-81821 paragraph 3.2.6; also see MIL-A-8421 and DOD Inst. 3224.1
3.2.6.1 Disassembly for Shipment		MIL-T-81821; AFHRL-TP-84-49 paragraph 2.2.12a, b
3.2.7 Delivery		AFHRL-TP-84-49 paragraphs 2.1.1 and 2.2.12a
3.2.7.1 Installation		AFHRL-TP-84-49 paragraph 2.2
3.3 Design and Construction		
3.3.1 Materials, Parts, and Processes		MIL-STD-143 should be reviewed for selection of materials, parts, and processes. AFHRL-TP-84-49 paragraph 2.7.4
3.3.1.1 Parts Control Program		MIL-STD-965 paragraph 4.3.1 and other applicable paragraphs
3.3.1.1.1 Selection of Parts		MIL-STD-965 paragraph 3.3.1; AFHRL-TP-84-49 paragraphs 2.5.5 and 2.7.5
3.3.1.1.1.1 Parts Documentation		MIL-STD-965; MIL-STD-490 paragraph 20.3.1 1
3.3.1.1.1.2 Parts Control Exemptions		For exemptions see MIL-STD-965 paragraphs 4.7, 4.8, and 4.9; Also see MIL-T-81821 paragraph 20.3.1.1
3.3.1.2 Conductor Identification		See color codes for MIL-STD-681
3.3.1.3 Terminal Ends		MIL-I-631
3.3.1.4a Spare Conductors	4.3.3	
3.3.1.4b Spare Conductors	4.3.3	

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.3.1.5 Finishes and Protective Coverings		For application of finishes select appropriate paragraphs from FED Spec. TT-L-32; Other requirements are listed in MIL-STD-808; For fungus control see Requirement 1 of MIL-STD-454. For blazing see MIL-B-7883. For painting see MIL-F-14072; Also see MIL-T-81821.
3.3.1.6 Power		
3.3.1.6.1 Primary Power Source		For mobile electric power see MIL-STD-633B; Also see MIL-T-81821; AFHRL-TP-84-49 paragraphs 2.2.8, 2.4.5, 2.4.6
3.3.1.6.1.1 Tolerances		AFHRL-TP-84-49 paragraph 2.2.9
3.3.1.6.2 Circuit Design		
3.3.1.6.3 Power Supplies		MIL-T-81821 paragraphs 3.2.1.11.7 and 3.2.1.11.8; AFHRL-TP-84-49 paragraphs 2.4.5, 2.4.6
3.3.1.6.4 Overload Protection		
3.3.1.6.5 Utility Power		See MIL-T-81821 paragraph 3.3.1.21.4 (for a two-panel trainer); AFHRL-TP-84-49 paragraphs 2.4.5, 2.4.6; For intercom (if needed) see MIL-C-299025; and MIL-T-81821 paragraph 3.3.1.21.4.2 for accessible receptacles
3.3.1.6.6 Main Power Distribution Panel		MIL-T-81821 paragraph 3.3.1.21.6; Location of panel MIL-T-81821 paragraph 3.3.1.21.6; Number of power control panels MIL-T-81821 paragraph 3.3.1.21.6; Master-keyed lock switch MIL-T-81821 paragraph 3.3.1.21.6; Power-on light MIL-T-81821 paragraph 3.3.1.21.6.4
3.3.1.6.7a Power Interruption and Transients		AFHRL-TP-84-49 paragraph 2.4.12
3.3.1.6.7b Power Interruption and Transients		
3.3.1.6.8 Grounding		MIL-T-81821 paragraph 3.3.1.24.2; AFHRL-TP-84-49 paragraph 2.2.9
3.3.1.6.9 Wiring, General		MIL-T-81821 (Page 31); Also see MIL-W-5088 (select appropriate paragraphs)

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.3.1.8.9.1 Wiring Requirements		Wire bundling MIL-T-81821 paragraph 3.3.1.29.1; shielding MIL-T-81821 paragraph 3.2.1.30; Insulation protection MIL-T-81821 paragraph 3.3.1.24.5; Printed wiring see Requirement 10 of MIL-STD-454; Slack MIL-T-81821; Voltage drop MIL-W-8160; Current-carrying capacity MIL-W-8160
3.3.1.7 Mechanical Connectors		MIL-S-45743; Also see MIL-T-81821 paragraphs 3.3.1.33 and 3.3.1.34
3.3.1.8 Time Totalizers		MIL-T-81821 paragraph 3.3.1.22, MIL-M-7793;
3.3.1.9 Screw and Pipe Threads		Requirement 12 of MIL-STD-454; Also see National Bureau of Standards, Handbook H28
3.3.1.10 Thermal Design		Heat control see Requirement 52 MIL-STD-454; Blowers MIL-B-2307 (Page 21); Colling MIL-T-81821 paragraph 3.2.1.8
3.3.1.11 Fasteners		Trainer-peculiar fasteners MIL-T-81821 paragraph 3.3.1.13 and MIL-STD-454
3.3.2 Electromagnetic Compatibility		AFR 100-54, MIL-STD-461, MIL-STD-463, MIL-E-6051, and MIL-STD-462
3.3.3a Name Plates and Product Marking, General		MIL-STD-130
3.3.3b Name Plates and Product Marking, General		MIL-STD-1472
3.3.3c Name Plates and Product Marking, General		MIL-STD-12
3.3.3.1 Name Plates		MIL-T-81821 paragraph 3.3.3.2 and 3.3.3.5; Also see MIL-STD-26715; MIL-STD-482A, Appendix II (Page II-3); For computer program configuration item see MIL-STD-483
3.3.3.2 Parts Identification		MIL-T-81821 paragraph 3.3.3.6; Also see ANS1Y32.10; MIL-STD 17 ANS1Y32.2

PRIME DEVELOPMENT SPECIFICATION	ISD-DERIVED TRAINING EQUIPMENT DESIGN	OTHER SOURCES
3.3.3.3 Cover Markings		Cover fabric see Spec. No. 16PSO28A paragraph 3.3.3.13, MIL-C-20696, and FED-STD-595; Hardcover Spec. No. 16PSO28A paragraph 3.3.3.14 for an example and MIL-T-81821 paragraph 3.3.3.7.2; Construction of covers MIL-T-81821 paragraphs 3.7.5, 3.7.5.1, 3.7.5.2, and 3.7.5.3; Cover markings MIL-T-81821 paragraph 3.3.3.7; Security covers MIL-T-81821 paragraph 3.3.3.7.1; Installation of covers MIL-T-81821 paragraphs 3.3.3.17 and 3.3.3.18; and Cover handles MIL-T-81821 paragraph 3.3.3.18a
3.3.3.4 Precautionary Markings		MIL-T-81821 paragraphs 3.3.3.9 and 3.3.3.10
3.3.3.5 Safety Markings		MIL-T-81821 paragraphs 3.3.3.20 and 3.3.6.1
3.3.3.6 Electrical Power Markings		MIL-T-81821 paragraphs 3.3.3.13
3.3.3.7 Shipping and Storage Markings		MIL-T-81821 paragraph 3.3.3.23; Also see MIL-STD-129
3.3.3.8 Other Markings		Center-of-balance markings MIL-T-81821 paragraph 3.3.3.8; Electric motor markings MIL-T-81821 paragraph 3.3.3.11; Hoisting instruction/markings MIL-T-81821 paragraph 3.3.3.19 (Also see paragraph 5.9.11.3.2 of MIL-STD-1972 Table X); Marking of fluids and gases MIL-T-81821 paragraph 3.3.3.12 (Also see MIL-STD-1247); Selectionalized components MIL-T-81821 paragraph 3.3.3.14; Power switch marking MIL-T-81821 paragraph 3.3.3.15; Fluid tanks MIL-T-81821 paragraph 3.3.3.16; FED-STD-595
3.3.4 Workmanship		Requirement 9 of MIL-STD-454; Welding MIL-W-8604 and MIL-W-8611
3.3.5 Interchangeability		Requirement 7 of MIL-STD-454; MIL-STD-100; MIL-T-81821; For an example see Spec. No. 16PSO28A paragraphs 3.3.5.1, 3.3.5.2, and 3.3.5.3
3.3.6a Safety, General		
3.3.6b Safety, General		MIL-STD-882; Requirement 1 of MIL-STD-454; MIL-STD-1472; Also see MIL-T-23991E paragraph 3.3.6
3.3.6.1a Hazardous Material		
3.3.6.1b Hazardous Material		
3.3.6.2 Fire Detection		AFHRL-TP-84-49 paragraph 2.2.14; Also see NFPA Standard 72E and DN6D2 of AFSC DH 1-6
3.3.6.2.1 Fire Alarm		

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.3.6.2.2 Facility Fire Control Interface		MIL-T-81821 paragraph 3.3.6.2; AFHRL-TP-84-49 paragraph 2.2.14
3.3.6.3 Overheat Sensing		
3.3.6.4 Fire Stop Sealing		AFHRL-TP-84-49 paragraph 2.2.14
3.3.6.5a Emergency Power-Off		
3.3.6.5b Emergency Power-Off		FED-STD-595
3.3.6.6 Other Safety Requirements		
3.3.6.7 Acoustic Noise		
3.3.6.7.1a Hazardous Noise		
3.3.6.7.1b Hazardous Noise		See AFR 161-35
3.3.6.7.2 Speech Interference Noise Level		AFHRL-TP-84-49 paragraph 2.4.9
3.3.6.8 Safety Design		Also see DN2C2, DN2E1, 2, 3, DN2E4; DN4A2, DN5D2, DN6A1-7, DN4E1-2, DN4C1-3 of AFSCD 1-6
3.3.7 Human Performance/ Human Engineering		MIL-T-81821 paragraph 3.3.7; MIL-T-1472; MIL-H-46855; The Human Engineering Guide to Equipment Design; AFHRL-TP-84-49 paragraph 2.4.4
3.4 Documentation		Review Data Item Description (DIDs); AFHRL-TP-84-49 paragraphs 2.2.12c, 2.2.13(a, b), 2.4.3, 2.5.2, 2.7.10
3.5 Logistics		
3.5.1a Maintenance Concept		For an example see Specification No. 16PSO28A paragraph 3.5.1; Also see MIL-STD-490 paragraph 20.3.5.1. Also see AFHRL-TP-84-49 paragraphs 2.1.6 and 2.5.1
3.5.1b Maintenance Concept		
3.5.2 Supply		AFHRL-TP-84-49 paragraphs 2.4.1, 2.4.2, 2.6.9
3.5.3 Facility and Facility Equipment		AFHRL-TP-84-49 paragraph 2.4.7
3.6 Personnel and Training		AFHRL-TP-84-49 paragraph 2.7.7
3.6.1 Personnel		MIL-STD-490 paragraph 20.3.6.1; AFHRL-TP-84-49 paragraph 2.5.3
3.6.2 Training		MIL-STD-490 paragraph 20.3.6.2; AFHRL-TP-84-49 paragraph 2.3.2
3.7 Major Component Characteristics		Depends upon components being specified
3.7.1a Instructional System Programs		AFHRL-TP-84-49 paragraphs 2.6.2, 2.6.7, 2.7.6, 2.7.7
3.7.1b Instructional System Programs		
3.7.1c Instructional System Programs		
3.7.1d Instructional System Programs		
3.7.1.1a General Requirements		
3.7.1.1b General Requirements		
3.7.1.1c General Requirements		
3.7.1.1d General Requirements		

PRIME DEVELOPMENT SPECIFICATION	ISD-DERIVED TRAINING EQUIPMENT DESIGN	OTHER SOURCES
3.7.1.1e General Requirements		
3.7.1.1f General Requirements		
3.7.1.1g General Requirements		
3.7.1.1h General Requirements		
3.7.1.1i General Requirements		
3.7.1.1j General Requirements		
3.7.1.1k General Requirements		
3.7.1.2a Training/Simulation Programs		
3.7.1.2b Training/Simulation Programs		
3.7.1.2c Training/Simulation Programs		
3.7.1.3a Instructional Features Program	5.2.1, 5.2.2a, 5.2.2b, 5.2.3, 5.2.5, 5.2.6, 5.2.7, 5.2.8, and 5.2.9	
3.7.1.3b Instructional Features Program		
3.7.1.3c Instructional Features Program		
3.7.1.4 Instructional Text Programs		
3.7.1.5a Documentation		AFHRL-TP-84-49 paragraphs 2.1.5 and 2.6.5
3.7.1.5b Documentation		No blanks to be completed but see DI-E-30140, DI-E-3277/M, and DI-E-30139
3.7.2 Computational System		
3.7.2.1 Computational Resources		
3.7.2.1.1 Computational System Hardware		
3.7.2.1.1.1 Multiprocessor/Multicomputer Complex		
3.7.2.1.1.2 Computational System Hardware Documentation		
3.7.2.1.2 Computer Program System		AFHRL-TP-84-49 paragraphs 2.1.3, 2.6.3, 2.6.4, 2.7.8
3.7.2.1.2.1 Programming Language		
3.7.2.1.2.2 CPS Organization and Preparation		
3.7.2.1.2.2.1 Trainer Subsystems Support Computer Programs		
3.7.2.1.2.2.2 Maintenance and Test Computer Programs		AFHRL-TP-84-49 paragraph 2.1.5
3.7.2.1.2.2.3 Operational Readiness Computer Programs		
3.7.2.1.2.3 CPS Documentation		
3.7.2.2 Computational Subsystem		
3.7.2.2.1 Computational Subsystem Hardware		
3.7.2.2.1.1 Computational Equipment Performance Characteristics		
3.7.2.2.1.1.1 Computational Requirements		
3.7.2.2.1.1.2 Interrupt Provisions		
3.7.2.2.1.1.3 Interval Timing Provisions		
3.7.2.2.1.1.4 Real-Time Clock		
3.7.2.2.1.1.5 Bootstrap Loading Provisions		
3.7.2.2.1.1.6 Power Failure Hardware		

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.7.2.2.1.2 Input/Output Hardware		
3.7.2.2.1.3 Interface Hardware		
3.7.2.2.1.4 Peripheral Equipment		AFHRL-TP-84-49 paragraph 2.1.11
3.7.2.2.1.4.1 Mass Storage Equipment		
3.7.2.2.1.4.1.1 Primary Mass Storage		
3.7.2.2.1.4.1.2 Secondary Mass Storage		
3.7.2.2.1.4.2 User Interface Equipment		
3.7.2.2.1.4.2.1 Operator Consoles		
3.7.2.2.1.4.2.2 Support Consoles		
3.7.2.2.1.4.3 Hardcopy Equipment		MIL-STD-188, Appendix C (Table 2)
3.7.2.2.1.4.4 Additional Peripheral Equipment		
3.7.2.2.1.5 Computational Subsystem Spare Capability and Growth Capability		AFHRL-TP-84-49 paragraphs 2.6.8, 2.7.2, 2.7.3
3.7.2.2.1.5.1a Spare Processing Time		
3.7.2.2.1.5.1b Spare Processing Time		
3.7.2.2.1.5.1c Spare Processing Time		
3.7.2.2.1.5.2 Spare Memory or Memory Expansion Capability		
3.7.2.2.1.5.3 Input/Output Expansion		
3.7.2.2.1.5.4 Interface Hardware Spare Expansion		
3.7.2.2.1.5.5a Primary Mass Storage Spare and Growth		
3.7.2.2.1.5.5b Primary Mass Storage Spare and Growth		
3.7.2.2.1.5.6 Physical and Environmental Characteristics		
3.7.2.2.2 Computational Subsystem Computer Programs/Data		
3.7.2.2.2.1 Supervisor/Executive Computer Program		
3.7.2.2.2.1.1 Power Failure Computer Programs		
3.7.2.2.2.1.2 Debug Computer Programs		
3.7.2.2.2.2 Input/Output Computer Programs		
3.7.2.2.2.3 Computational Subsystem Mission Support: Corporate Programs/Data		
3.7.2.2.2.3.1 Mass Storage Copy/Comparator Programs		
3.7.2.2.2.3.2 Computational Subsystem Mission Support Documentation		
3.7.2.2.2.4 Computational Subsystem Maintenance and Test Computer Programs		AFHRL-TP-84-49 paragraph 2.1.5
3.7.2.2.2.4.1 Computer Equipment Diagnostic Computer Programs		
3.7.2.2.2.4.2 Interface Hardware Diagnostic Computer Programs		
3.7.2.2.2.4.2.1 Discrete Input and Output Tests		
3.7.2.2.2.4.2.2 Analog Input and Output Tests		
3.7.2.2.2.4.3 Trainer Equipment Test Computer Programs		

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.7.2.2.2.4.4 Calibration Test Computer Programs		
3.7.2.2.2.4.5 Spare Capacity Verification Computer Programs		
3.7.2.2.2.4.5.1 Spare Processing Time Verification Computer Programs		
3.7.2.2.2.4.5.2 Spare Memory/On-Line Primary Mass Storage Verification Computer Programs		
3.7.2.2.2.4.6 Computational Subsystem Maintenance and Test Documentation		
3.7.2.3 Trainer Support Subsystem (TSS)		
3.7.2.3.1 Modification Support Hardware		
3.7.2.3.1.1 TSS Computational Hardware		
3.7.2.3.1.1.1 TSS Computer Equipment Performance		
3.7.2.3.1.2 TSS Peripheral Equipment		
3.7.2.3.1.2.1 TSS Mass Storage Equipment		
3.7.2.3.1.2.2 Modification Support Consoles		
3.7.2.3.1.2.3 TSS Hardcopy Equipment		
3.7.2.3.1.2.4 Additional Modification Support Peripheral Equipment		
3.7.2.3.1.3 TSS Spare Capacity and Growth Capability		
3.7.2.3.1.3.1 Memory Spare or Growth		
3.7.2.3.1.3.2a Mass Storage Spare and Growth		
3.7.2.3.1.3.2b Mass Storage Spare and Growth		
3.7.2.3.1.3.3 Input/Output Expansion		
3.7.2.3.1.4 TSS Physical and Environmental Characteristics		
3.7.2.3.2 TSS Maintenance and Test Computer Programs		
3.7.2.3.2.1 TSS Computer Equipment Diagnostic Computer Programs		
3.7.2.3.2.2 TSS Equipment Test Computer Programs		
3.7.2.3.2.3 Spare Capacity Verification Computer Programs		
3.7.2.3.2.3.1 Spare Memory and Mass Storage Verification Computer Programs		
3.7.2.3.3 Modification Support Computer Programs/Data		
3.7.2.3.3.1 TSS Operating System		
3.7.2.3.3.2 Compilers/Assemblers		
3.7.2.3.3.3 Loaders		
3.7.2.3.3.4 Data Base Management Computer Programs		
3.7.2.3.3.5 Text Editors		
3.7.2.3.3.6 Development Tools		
3.7.2.3.3.7 TSS Mass Storage Copy/Comparator Computer Programs		

PRIME ITEM DEVELOPMENT SPECIFICATION	ISD BASED TRAINING EQUIPMENT DESIGN SPECIFICATION	OTHER SOURCES
3.7.2.3.4 Modification Support Documentation		AFHRL-TP-84-49 paragraph 2.5.6
3.7.2.3.4.1 Hardware Modification Support Documentation		
3.7.2.3.4.2 CPS Modification Support Documentation		
3.7.2.3.5 Subsystem-Unique Modification Support Requirements		
3.7.2.3.5.1 Computational Subsystem Modification Support		
3.7.2.3.5.1.1 CPS Generation Computer Programs		
3.7.3 Other Major Components		MIL-T-81821 paragraphs 3.7.2.1 and 3.7.2.2
3.8a Precedence		
3.8b Precedence		
4.0 Quality Assurance Program		
4.1 Quality Assurance Program, General		MIL-Q-9858; MIL-T-81821 paragraphs 4.1 and 4.1.1; Also see MIL-STD-483 for tests dealing with computer programs; AFHRL-TP-84-49 paragraphs 2.3.1 and 2.3.3
4.1.1a Responsibility for Tests		MIL-STD-490, paragraph 10.4.1.1
4.1.1b Responsibility for Tests		MIL-T-81821 paragraph 4.1.1
4.1.1.1 Test Schedule		
4.1.2a Special Tests/Specific Tests		MIL-T-81821, paragraph 4.2.4.2
4.1.2b Special Tests/Specific Tests		MIL-T-81821, paragraph 4.2.4.4
4.1.2c Special Tests/Specific Tests		MIL-T-81821 paragraph 4.2.4.4.1
4.1.2d Special Tests/Specific Tests		ATC Training Equipment Acceptance Demonstration Checklist (ATC Form 514) (Section 4); MIL-STD-483 paragraph 60.4.4.1.1 (Page 46); Functional configuration unit (FCA) Page 47; paragraphs 120.6 and 120.6.1; Physical configuration unit (PCA) (Pages 96 and 97)
4.1.2e Special Tests/Specific Tests		MIL-T-81821 paragraph 4.2.4.1 MIL-STD-1472
4.1.2f Special Tests/Specific Tests		Electromagnetic interference suppression tests MIL-T-81821 paragraph 4.4.2.2.9; Environmental tests MIL-STD-810; Temperature measuring MIL-T-81821 paragraph 4.2.4.2.5; Controls and control circuits MIL-T-81821 paragraph 4.2.4.5.2; Functional tests MIL-T-81821 paragraph 4.2.4.5.3; Structural tests MIL-T-81821 paragraph 4.2.4.5.4; Power test MIL-T-81821 paragraph 4.2.4.5.5
4.2 Verification Cross-Reference Index		
5.0 Preparation for Delivery		MIL-T-81821
6.0 Notes		MIL-STD-490

APPENDIX C

PREPARATION WORKSHEET

PREPARATION WORKSHEET

Identification Number	Title	Blanks		To be Included		Page Ref.	Comments
		Y	N	Y	N		
1.0	Scope		X			61	
1.1	General	X				61	
1.2	Application		X			61	
1.3	Deviation		X			62	
2.0	Applicable Documents		X			63	
2.1	Issue of Documents	X				63	
2.2	Availability of Documents	X				66	
3.0	Requirements		X			68	
3.1	Trainer Description	X				68	
3.1.1	Item Diagram(s)	X				74	
3.1.2	Interface Definition(s)	X				77	
3.1.3	Major Component List	X				79	
3.1.4	Government Furnished Property List	X				92	
3.1.5	Government Loaned Property List	X				94	

PREPARATION WORKSHEET

Identification Number	Title	Blanks		To be Included		Page Ref.	Comments
		Y	N	Y	N		
3.2	Characteristics		X			95	
3.2.1	Performance	X				95	
3.2.1.1	Training Objectives	X				95	
3.2.1.2	Tasks to be Trained	X				98	
3.2.1.3	Malfunctions to be Simulated	X				100	
3.2.1.3.1	Maintenance Concept of Operational Equipment	X				106	
3.2.1.4	Fidelity Levels		X			107	
3.2.1.4.1	Fidelity Levels of Simulated Equipment	X				108	
3.2.1.4.2	Environmental Fidelity	X				111	
3.2.1.4.3	Probable Engineering Changes	X				112	
3.2.1.5	Instructional Capabilities	X				117	
3.2.1.5.1	Initialization and Warm-Up	X				118	
3.2.1.5.2	Malfunction Exercise Selection	X				121	

PREPARATION WORKSHEET

Identification Number	Title	Blanks		To be Included		Page Ref.	Comments
		Y	N	Y	N		
3.2.1.5.3	Monitoring Student Performance	X				124	
3.2.1.5.4	Freeze Capability	X				126	
3.2.1.5.5	Augmented Feedback Capabilities	X				130	
3.2.1.5.6	Next Activity Control Features	X				132	
3.2.1.5.7	Stimulus Control Features	X				134	
3.2.1.5.8	Cue Enhancement Control Features	X				136	
3.2.1.5.9	Sign-In Capability	X				137	
3.2.1.6	Utilization	X				138	
3.2.1.7	Useful Life/Operational Service Life	X				140	
3.2.2	Physical Characteristics		X			142	
3.2.2.1	Weight Limits	X				142	
3.2.2.2	Physical Dimensions	X				143	

PREPARATION WORKSHEET

Identification Number	Title	Blanks		To be Included		Page Ref.	Comments
		Y	N	Y	N		
3.2.2.3	Moments	X				145	
3.2.2.4	Work and Storage Areas	X				146	
3.2.2.5	Attachment of Components	X				147	
3.2.2.6	Other Dimensions and Tolerances	X				148	
3.2.2.7	Other Physical Properties		X			148	
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3.7.2.2.2.3.1	Mass Storage Copy/Comparator Programs	X				312	
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3.7.2.2.2.4.4	Calibration Test Computer Programs		X			316	
3.7.2.2.2.4.5	Spare Capacity Verification Computer Programs		X			317	
3.7.2.2.2.4.5.1	Spare Processing Time Verification Computer programs	X				317	
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3.7.2.3.1.2	TSS Peripheral Equipment		X			323	
3.7.2.3.1.2.1	TSS Mass Storage Equipment		X			323	
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3.7.2.3.4.1	Hardware Modification Support Documentation		X			335	
3.7.2.3.4.2	CPS Modification Support Documentation		X			335	
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3.7.2.3.5.1	Computational Subsystem Modification Support		X			336	
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